Working Group on Widely Distributed Stocks (WGWIDE)
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Identification of new reference fleets regarding striped red mullet from professional fishing data for Subareas 7 and 8.

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Context

For striped red mullet (*Mullus surmuletus*), there is no scientific campaign to provide one or more robust abundance indices for the mur-west stock. One of the objectives of the ACOST project is therefore to construct, and in some cases consolidate, abundance indices based on commercial fishing data. Classically, two approaches can be developed to build such indices:

- the "design-based" approach, based on the selection of representative statistical units (in this case, vessels), from which data are then collected to build an abundance index;
- the "model-based" approach, which, on the other hand, studies the variability of catch data and reworks them to construct such an index.

The design-based approach was initiated during the ROMELIGO project (Léauté et al., 2018). It is based on a data-filtering method that examines the activity of fishing fleets that are potential candidates to be retained to provide an index of abundance through mandatory and optional criteria. These criteria were defined and discussed throughout the project in working groups involving the fishing industry. At the end of the ROMELIGO project, five reference fleets were proposed because their Landings Per Unit Effort (LPUE) were considered to be potentially able to account for the level of abundance of striped red mullet in the Bay of Biscay (ICES Subarea 8) (Léauté et al., 2018 with publication of the method in Caill-Milly et al., 2019). These fleets were as follows:

- « OTB » fleet - cluster 1 - mesh size class 70 - 79 mm;
- « GNS » fleet - cluster 2 - mesh size class 50 - 59 mm - 2nd quarter;
- « GNS » fleet - cluster 2 - mesh size class 50 - 59 mm - 3rd quarter;
- « GNS » fleet - cluster 2 - mesh size class 60 - 69 mm - 2nd quarter;
- « GNS » fleet - cluster 2 - mesh size class over 90 mm - 2nd quarter.

Since the ROMELIGO project, their CPUE has been updated and transmitted to ICES WGWIDE. Of the five original fleets, there are now four reference fleets, as the second one (« GNS » fleet - cluster 2 - mesh size class 50 - 59 mm - 2nd quarter) has been withdrawn as its use reached a very low level (around 40 fishing trips in 2018).

Within the framework of the ACOST project and for this ICES Subarea 8, the present work aims to consider the interest of a new fleet using Danish seines. The latter were not considered before because the time series was too short. The interest of an extent of the methodology

to ICES Subarea 7 and/or ICES Subareas 7 and 8 for OTB, GNS and SDN is also viewed to take into account the entire geographical area delimiting the mur-west stock.
NB: the ACOST project also deploys a model-based approach based on the standardization of LPUE using statistical models. It has been used for whiting and pollack, and is currently being adapted for red mullet, to be communicated to WGWIDE at a later date.

This WD refers only to new results obtained with the design-based approach.

1. Data and approach

1.1. Data origin

The data used relate to commercial fishing catches and are of two types: data regarding landings (SACROIS data) and data regarding discards (OBSMER data). SACROIS data have been available since 2000; they were extracted for the period 2000-2022. For the area corresponding to the spatial delimitation of the mur-west stock, 3,263,982 fishing trips were related to striped red mullet catch (each line containing the quantity of red mullet landed per fishing trips and per vessel). It therefore represents a quantification of landings per unit effort (LPUE). OBSMER data have been available since 2003; they were extracted for the period 2003-2021. To use the OBSMER data, the following criteria were considered: the availability of a sufficient number of observations, the proportion of discards mean by month and by year from the number of total operations realized and observed, the stability of this proportion over time, and the size composition of the discards. Regarding size, there is no minimum size in force for striped red mullet, but a minimum commercial weight set at 40 grams, equivalent to individuals of around 18 cm. For the area corresponding to the spatial delimitation of the mur-west stock, 6,504 fishing operations were observed entirety (landing part, discard part, all species). Their breakdown by Subarea and by gear is provided in Table 1.

Table 1: Number of fishing operations observed according to the Subareas and gears considered over the 2003-2021 period.

	OTB	GNS	SDN
Subarea 7	3 453	383	353
Subarea 8	1 001	941	373

Regarding the vessels, their technical characteristics may change over time as a result of modifications (such as remotorization, changes in fishing gear, etc.). In order to provide the most accurate information throughout a vessel's life cycle, the annual characteristics were collected from the Community fishing fleet register (https://webgate.ec.europa.eu/fleet-europa/search_en).

1.2. Selection, cleaning and data preparation

Three gears were selected using their FAO code: "OTB" for the bottom otter trawls (1 vessel), "GNS" for the set gillnets and "SDN" for the Danish seines. As OBSMER data for OTB and GNS in Subarea 8 has already been processed by Léauté et al. (2018), these data were not considered in this report.

1.2.1. Data extraction and definition of the study population

Differences in activity for the three gears exist between Subarea 7 and Subarea 8 (seasonality, average vessel length, year of first use of gear, etc.). Analyses by gear are therefore initially undertaken separately for these two Subareas:

- For Subarea 7, the spatial coverage selection corresponds to ICES divisions "27.7.a", "27.7.b", "27.7.c", "27.7.e", "27.7.f", "27.7.g", "27.7.h", "27.7.j" and "27.7.k";
- For Subarea 8, it corresponds to ICES divisions "27.8.a", "27.8.b", "27.8.c", "27.8.d" and "27.8.e".

The reference fleet selection for the construction of abundance indices consists in selecting vessels that will enable us to pinpoint the phenomenon of interest, namely striped red mullet catches. Therefore, vessels were selected in these 2 subareas, according to 2 criteria:

- Criterion 1: those having caught striped red mullet at least once between 2000 and 2020 for each Subarea;
- Criterion 2: only statistical rectangles consistent with the bathymetric distribution of striped red mullet were selected. They correspond to rectangles with bathymetries of less than 300 m and/or an intersection with this depth (except for rectangles 28E8 and 29E8, which have been excluded because they have a surface almost entirely in "27.7.d" and not in "27.7.e").

Vessels were then selected on the basis of activity, namely a realization of at least 24 fishing trips per year with striped red mullet, using trawls, nets or Danish seines respectively.
At the end of this first stage, 757 vessels formed the statistical population considered.

1.2.2. Data cleaning and final data set preparation

The “cleaning” related only to the landing data. It included detected outliers following expert opinions (atypical values of landings, unrealistic values of gear mesh sizes), data corresponding to vessels with fishing time equal to zero or not filled in and non-available data (fishing sequences without statistical rectangles information). The deletion also affected lines describing fishing sequences whose occurrence per month was less than 2 (as they cannot be used to consider the variability of landings for a given year, month, rectangle and gear) and the sequences for the year 2020 due to the health crisis linked to Covid19 and its impact on fishing activity (this year deemed too atypical to be considered for the fleet selection process).
For landings, to conduct the analyses, level indicators (mean, median) and dispersal indicators (interquartile range IQR, variance Var, standard deviation StD, and coefficient of variation CV) of the LPUE were calculated and displayed in columns using the following aggregation: year, month, rectangle, month, vessel registration, vessel length, vessel power, vessel tonnage, gear and gear mesh size (grouped in mesh class).
For discards, the calculated column parameters were the mean, the median and the standard deviation of the catches and the discards. The aggregation used was: year, month, rectangle and gear.

1.3. Analytical process of landing data to select a representative fleet

The approach was described by Caill-Milly et al (2019); only the main outlines are given hereafter.
Preliminary stage: a focus on discards is presented first due to the nature of the professional data available (related to landings). A condition for the indicators constructed to reflect abundance at the time of capture, it is first necessary to ensure that the loss of information linked to discards between catch and landing is controlled, or at least acceptable. To this end,

an analysis of OBSMER data was carried out for the pre-selected fleets; note that this consideration of discards is not always made in the literature.
Once this stage has been completed, the approach developed comprises four steps (Figure 1):

- a focus on the variability of LPUE and a hierarchization of causes (spatio-temporal variables, vessel and gear characteristics);
- a clustering to obtain a typology of vessels based on the technical characteristics of the vessels that emerge as the main explanatory factors for the variability of LPUE (excluding spatio-temporal variables);
- analysis of average LPUE per cluster. To identify clusters (or fleets) particularly useful for providing an overview of abundance, a multi-criteria approach with mandatory and optional conditions was applied (Table 2); it sets conditions for the level, variability and duration of activity and is applied for each cluster. Then for these conditions, a points system was developed. Points were attributed by expert opinion on a scale of 3 (1 - null or weak; 2 - medium; 3 - strong);

Table 2: Mandatory and optional conditions applied to identify the cluster of interest

Mandatory conditions	**Optional conditions**
- a sufficient number of vessels constituting the cluster, set at a minimum of 10 for OTB, GNS and SDN; - presence in the subarea for a long period. It is considered here that the series must be available for a period longer than the maximum longevity known for striped red mullet, *i.e.* 12 years; - a sufficient average level of LPUE. The value for this criterion varies according to the gear. It is set at 5 kg for nets and trawls, and 10 kg for Danish seines, based on an examination of LPUE values.	- a seasonal signal stable in amplitude and periodicity; - activity north and south of the Bay of Biscay for Subarea 8, in 7e-k for Subarea 7; - moderate seasonal variability.

- Once selected, fleets were refined using gear mesh sizes or mesh classes, and possibly seasonal (quarterly) activity considerations.

NB : the analyses carried out to identify new reference fleets were started in 2021; they were therefore conducted over the 2005-2019 period for trawl and net, and over the 2007-2019 or 2008-2019 period for Danish seine (2020 having been excluded due to COVID). Since the start of these analyses, other years have become available: 2021 and 2022. The question of their impact on the results if they had been included in the analyses was therefore raised at the WG Reference Fleet associating the professional structures. Steps 1 to 2 were therefore reworked to take them into account. The results are similar to the previous ones in terms of fleet selection. This does not justify repeating all the graphs and tables presented (because of the time it would take). However, for the fleets selected, the "number of uses" and "average LPUE" indicators were updated using the latest SACROIS database available, which includes 2021 and 2022.

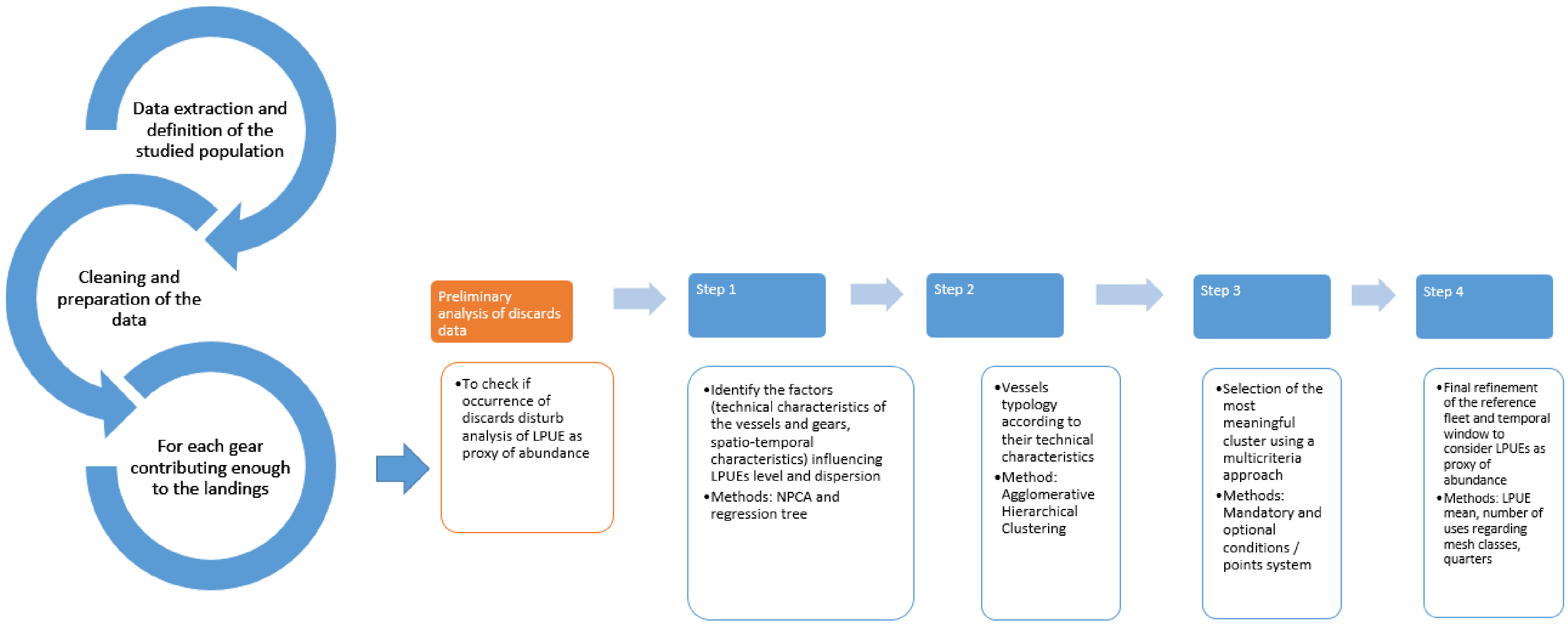

Figure 1: Retained methodology for the identification of reference fleets from the LPUE study (from Caill-Milly, 2023)

1.4. Engagement of organizations representing professional fishermen

As with the ROMELIGO project, exchanges with professional representatives have been organized throughout the ACOST project. These took place in Working Groups (WG) "Reference Fleets", attended by scientists, representatives of producers' organizations, fisheries committees and Aglia.... These groups enable scientists to present the data used and the method(s) selected, to discuss the relevance of thresholds and aggregations, to detect possible biases linked to changes in regulations (from local to European level), etc. in the construction of indices. Appendix 1 details the progress of the WGs regarding striped red mullet. The approach adopted can be described as collaborative research. The nature of the collaboration with professional representatives is presented in Table 3, given that the entire project is not yet complete.

Table 3: Detailed participation of the professional stakeholders in the various stages of the ACOST research project by 08/31/2023, using the modalities described by Macher et al. (2022)

Nature of the collaboration	**Realization ACOST framework by 31/08/2023**	**Comments**
Stakeholder participation in data analysis		
Stakeholder participation in project management		
Stakeholder participation in interpreting results	X	
Stakeholder participation in financing project	X	
Stakeholder participation in disseminating results	(X)	Planned but not yet implemented as project in progress
Co-construction of research questions	X	
Stakeholder participation in data collection	X	By auto-sampling …
Stakeholder consultation/knowledge gathering	X	
Knowledge transfer from science to stakeholders	(X)	Planned but not yet implemented as project in progress

In terms of stakeholder engagement[1], ICES has recently produced a document describing the key principles of engagement in the work of the council and defining the roles of the professional parties as well as those of scientists (ICES, 2023a). In addition, ICES organized a workshop in May 2023 dedicated to the implementation of this stakeholder engagement strategy (WKSTIMP). This provided an opportunity to deepen some definitions and propose actions (ICES, 2023b). With reference to these two documents, and as far as the ACOST project is concerned, the reason for stakeholder involvement can be defined by the term "knowledge production", with stakeholders playing a "contributor" role. The last document also notes the importance of effective communication and learning for successful engagement. At the end of the ACOST project, feedback will be provided to professional structures to identify possible improvements for future projects.

[1] « ICES defines stakeholders as those who affect or are affected by a decision, process, or action of ICES, including scientists and knowledge providers operating within ICES network. Because of the central role that scientists in the network play in framing and conducting the work of ICES, scientists have a unique role as "internal stakeholders" from within the organization, and this strategy generally reserves the word "stakeholders" to denote all other stakeholders. » Extracted from ICES (2023).

2. Results for the data-filtering approach

For this WD and for the fleets studied (gear/Subarea combination) but not retained, the reasons for their exclusion are presented but not detailed. For each fleet selected, the presentation of results begins with the vessel typology. This typology is based on the technical characteristics that have the greatest influence on the variability of LPUE. Steps 2 to 4 are therefore presented and detailed. The figures and tables regarding the preliminary stage and step 1 are available in the appendixes 2, 3 and 4. This choice was made because all the stages have already been presented in a WD transmitted and presented to the WGWIDE in 2018 (Caill-Milly et al., 2018) for other fleets.

2.1. Applied to vessels using Danish seine (SDN) in Subareas 8 and 7

In previous work, the length of the Danish seine data series was too limited. This is no longer the case, so this document aims to consider the interest of the Danish seine metier in defining, or not, additional reference fleet(s).

For Subarea 8

Spatio-temporal factors are more important than technical characteristics in accounting for the variability of LPUE (Appendix 2). Once these factors have been removed, technical characteristics of the gear and vessels are highlighted. Regarding vessel characteristics and for SDN Subarea 8, they relate to gauge and length.

Vessel typology using technical characteristics and evolution of average LPUE for each cluster - Danish seine (SDN)

Implementation of Agglomerative Hierarchical Clustering (AHC) on the technical characteristics (gauge and vessel length) allows distinguishing two clusters (figure 2; characteristics displayed in table 4).

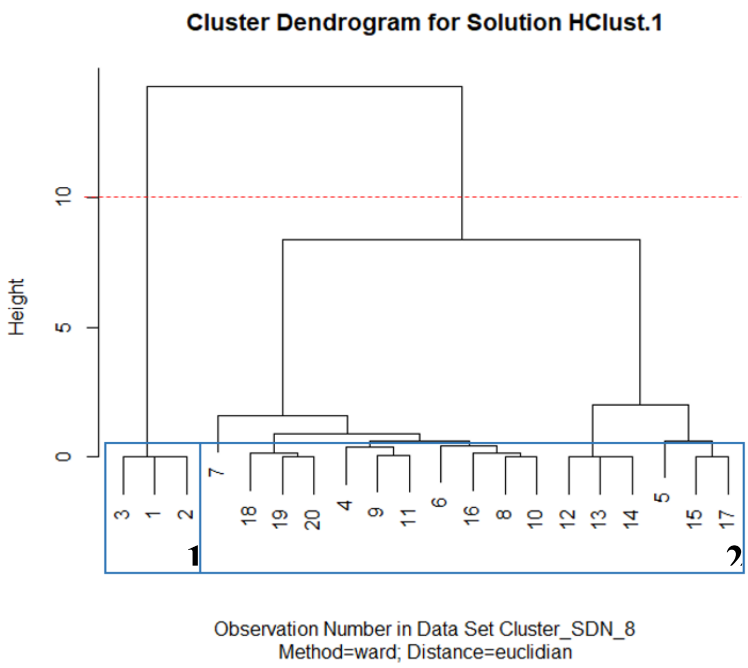

Figure 2: AHC of vessels using SDN in Subarea 8 according to their technical characteristics – gauge and length (standardized) (red line: visual cut)

Table 4 : Values of technical characteristics per cluster for vessels using SDN in Subarea 8

Cluster		Vessel length (m)			Gauge (grt)			Engine power (kW)		
Code	Number	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
1	3	34.0	34.0	34.0	274	274	274	588	588	588
2	17	18.0	22.0	24.9	88	149	227	331	459	626
Total	20									

For each candidate cluster, changes in landing average calculated by month and by year are shown in Figure 3. Cluster 1 displays highly variable activity (with a very high peak in 2009) at the start of the period, with a stop from 2014 onwards. Cluster 2 is only interrupted at the end of 2009/beginning of 2010, and shows a relative cyclicality in the LPUE levels.

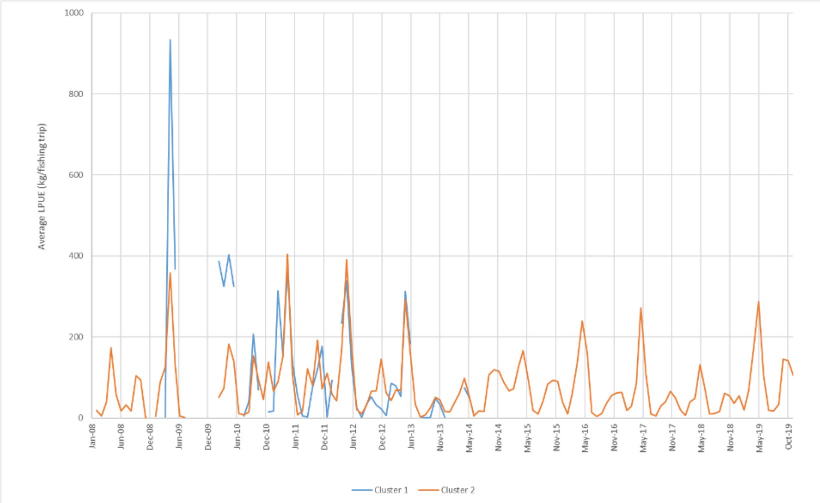

Figure 3: Average LPUEs of striped red mullet per cluster of vessels using SDN in Subarea 8

Within the area studied in the Bay of Biscay, an additional North (8a) / South (8b) division was applied. This division is made at latitude 46°0' N. In the northern part of the Bay of Biscay (delimitation 46°0' N) (Figure 4) and for each cluster, the average LPUE is very similar to that observed for the entire Bay.

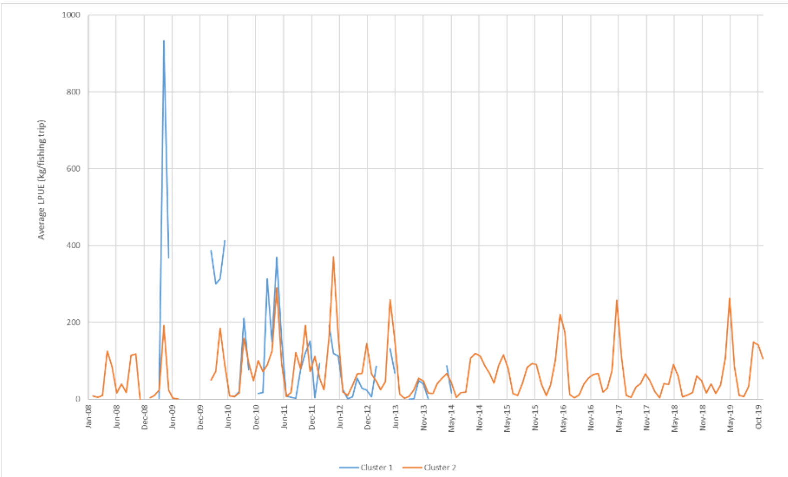

Figure 4: Average LPUEs of striped red mullet per cluster of vessels using SDN in the northern part of Subarea 8

In the southern Bay of Biscay (Figure 5) and for both clusters, the average LPUE is close to that observed for the whole Bay, but there are differences in levels for both clusters at some periods compared with Figure 3. Moreover, the series are discontinuous for both clusters.

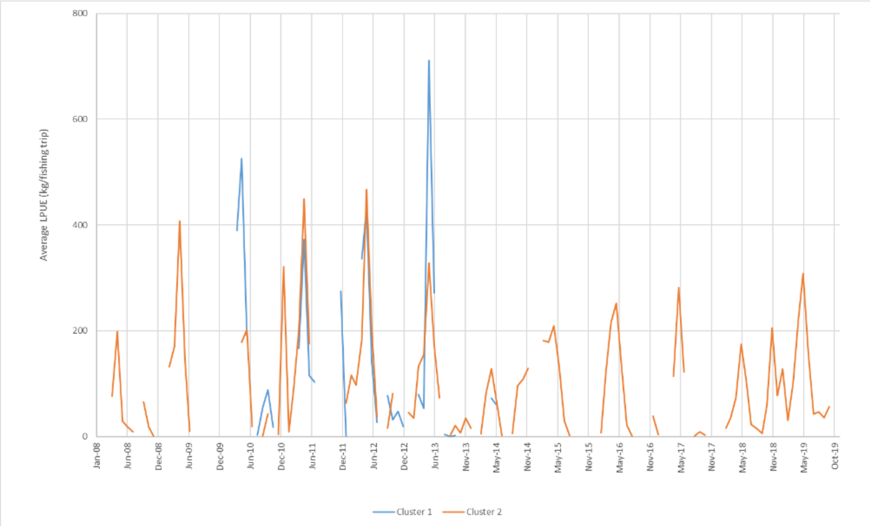

Figure 5: Average LPUEs of striped red mullet per cluster of vessels using SDN in the southern part of Subarea 8

LPUE levels differ according to the technical characteristics of the vessels. Among all the series observed, the northern Bay of Biscay shows the most cyclical and uninterrupted trend in average catch levels for Cluster 2.

Cluster selection with a multicriteria approach

Table 5 summarizes the results following the application of the madatory and optional conditions on the data series.

Table 5: Classification of clusters for SDN in Subarea 8

Multi-criteria selection method			
Level of obligation	Vessel typology (technical characteristics)	Cluster 1	Cluster 2
Mandatory	Sufficient number of vessels (> 10)		X
	Long data series (> 12 years)		X
	LPUE levels medium to high (> 10 kg/UE) over the period	X (133)	X (77)
Optional	Stable seasonal signal (both in amplitude and periodicity) during the series	1/3	2/3
	Activity present in N and S of the Bay of Biscay	1/3	2/3
	Moderate seasonal variability	1/3	2/3
Notation		3/9	6/9
Proposed ranking		2	**1**

The points system allows us to propose cluster 2 for Danish sein (SDN) in Subarea 8. This cluster 2 is composed of medium vessels with a mean length of 22 m (between 18.0 et 24.9 m), with a gauge between 88 and 227 grt, and an engine power between 331 and 626 kW.

The question of spatial selection was posed for Cluster 2. In order not to reduce the number of observations, and because the signals between the northern and southern Bay of Biscay were fairly similar, we chose to keep the whole Subarea 8 for this fleet. The following analyses therefore refer solely to this cluster.

Study of mesh sizes and seasonal variations in LPUE for Danish seine Cluster 2 (SDN)

Mesh sizes were considered according to several criteria: representativeness of the landing levels, continuity of use and a sufficient number of uses. The 70 mm mesh size is by far the most represented class for this cluster over the period (Figure 6).

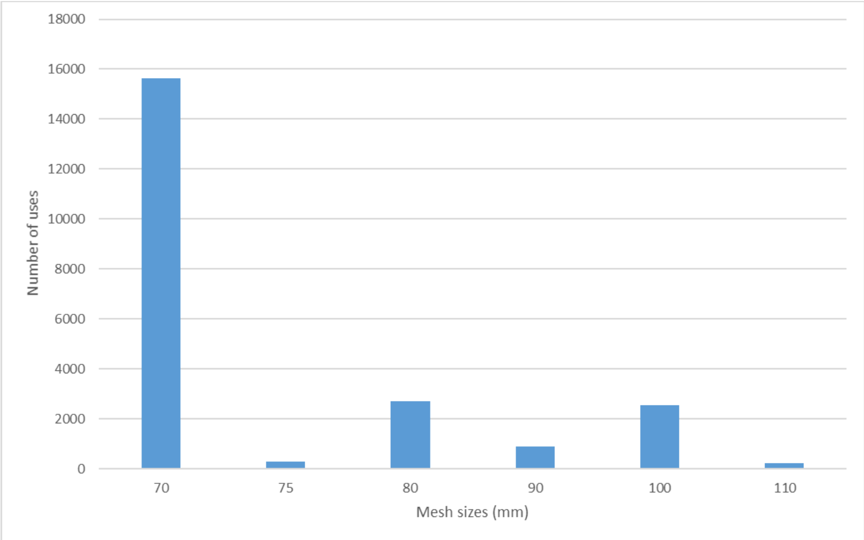

Figure 6: Number of mesh uses between 2008 and 2019 for Cluster 2 - Danish seine (SDN) - Subarea 8

Ffigure 7 shows the monthly evolution of LPUE for the three main meshes of cluster 2 (70 mm, 80 mm and 100 mm).

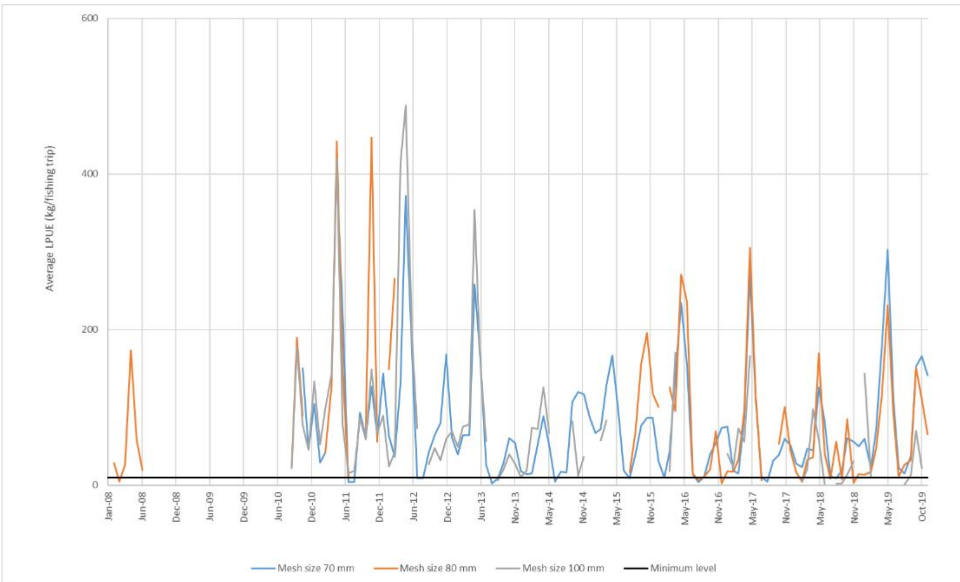

Figure 7: Monthly evolution of LPUE for the main mesh sizes used by Cluster 2 - Danish seine (SDN) - Subarea 8

For the criteria considered (Table 6), the 70 mm mesh size for the Danish seine (SDN) - cluster 2 is seen as the most interesting. This result, presented at the WG Reference Fleets, was discussed and it was decided to extend it to the 70-80 mm class. There are regulatory reasons for this, as some vessels previously working with 70 mm have already been required to use 80 mm in certain months as part of the management of the Bay of Biscay common sole stock[2]. The 70-80 mm class is therefore preferred, as it will make it possible to anticipate other possible 80 mm obligations for these vessels, and thus facilitate the construction of a long-term series.

Table 6: Mesh size results for Cluster 2 - Danish seine (SDN) - Subarea 8

	Proposed mesh size selection(s)					
Métier	Danish seine					
Cluster	2					
Mesh size (mm)	70	75	80	90	100	110
Sufficient LPUE level	X	X	X	X	X	X
Availability over a long period	X		X		X	
High number of uses	X					
Limited confidence interval	(X)	(X)	(X)		(X)	
Proposed mesh size	X					
Quarterly study	Yes					

For the 70-80 mm mesh class for SDN cluster 2, LPUE displays strong seasonality over the period, with higher levels in May. The confidence interval (CI) is also widest in May (Figure 8).

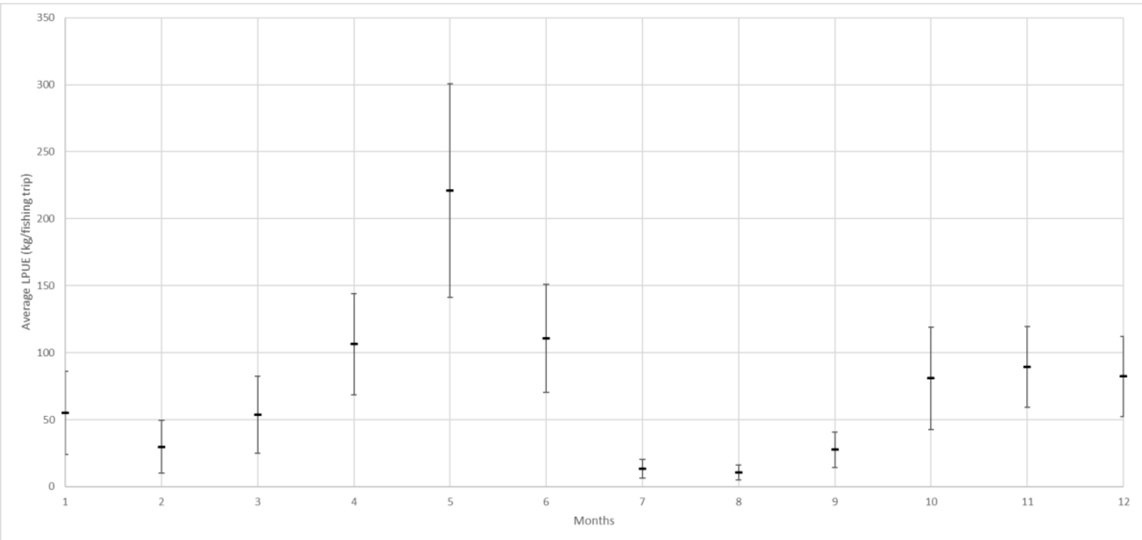

Figure 8: Average LPUE (with CI) per month over the period 2010-2019 for Cluster 2 - Danish Seine for mesh size class 70-80 mm - Subarea 8

Based on these characteristics, working on quarter 2 is proposed for this fleet.

[2] Arrêté du 12 février 2015 créant un régime national de gestion pour la pêcherie de la sole commune (Solea solea) dans le golfe de Gascogne (divisions CIEM VIII a et b)

Number of uses and LPUE levels per year

For cluster 2 - SDN with a 70 - 80 mm gear mesh size, the evolution of its use over time and of the LPUEs for the whole Bay of Biscay are considered.

The number of uses has been rising since 2012. It has reached a level of around 1,000 sequences per year since 2015, with 2021 marking the highest value in the series, with 1,356 sequences. The first LPUEs appear in 2008, with an interruption in 2010 (they only related to one vessel in 2008 and 2009). In 2011, average LPUE is high (around 270 kg/fishing trip). They fall until 2014 (67 kg/fishing trip), then rise between 2014 and 2016, then fall until 2018, before rebounding in 2019 to 210 kg/fishing trip. The last two years, 2021 and 2022, average around 100 kg/fishing trip (Figure 9).

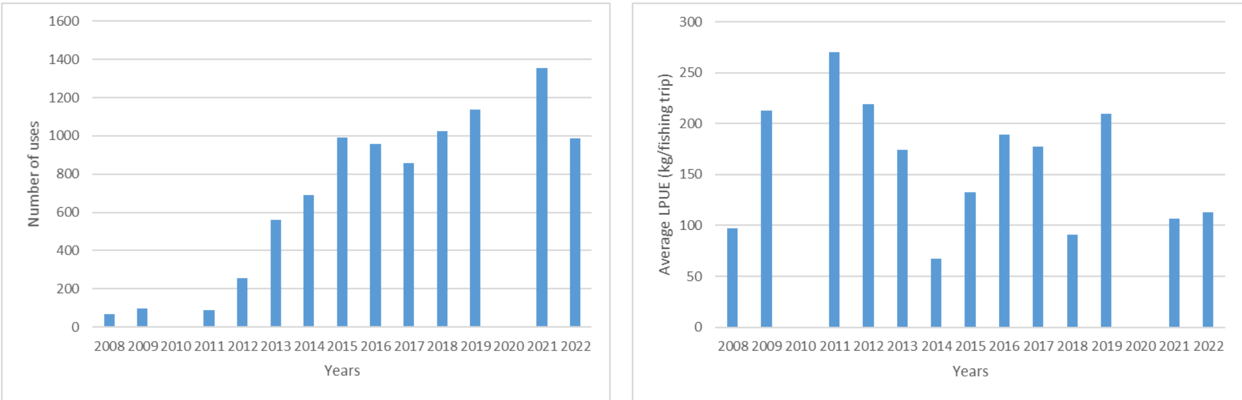

Figure 9: Number of uses and associated average LPUE levels for the Bay of Biscay - Danish seine - cluster 2 - mesh size class 70-80 mm - Quarter 2

For Subarea 7

Implementation of Agglomerative Hierarchical Clustering (AHC) on the technical characteristics accounting for the variability of LPUE (power engine) allows distinguishing two clusters (Figure 10). However, neither of these 2 clusters is made up of a sufficient number of vessels (5 and 2 respectively). In addition, the length of the LPUE series for the 2 clusters is insufficient (data not shown). There is therefore no Danish seine reference fleet proposed for Subarea 7.

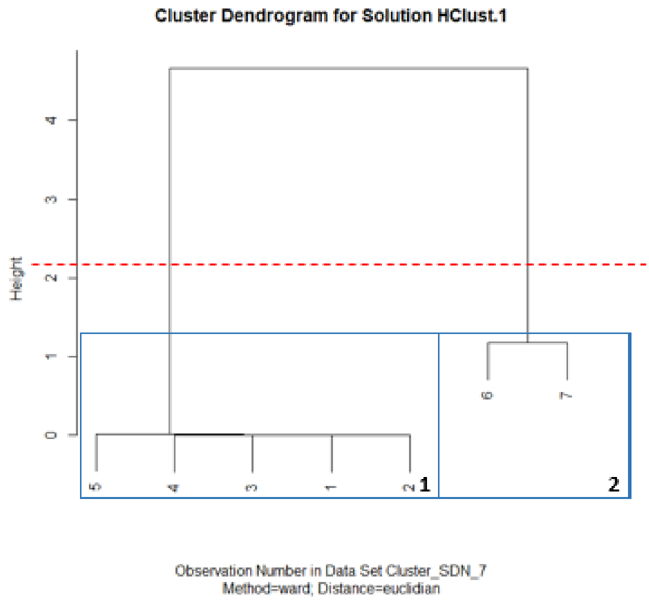

Figure 10: AHC of vessels using SDN in Subarea 7 according to their technical characteristics – engine power (standardized) (red line: visual cut)

Summary

The data-filtering method applied on vessels using Danish seine vessels allows to propose a reference fleet for the Bay of Biscay (Subarea 8). This fleet is composed of vessels using SDN with a mesh size of 70-80 mm in quarter 2 and having an average length of 22.0 m (between 18.0 and 24.9 m), an average gauge of 149 grt (between 88 and 227 grt) and an average engine power of 459 kW (between 331 and 626 kW).

No reference fleet is proposed for SDN in Subarea 7.

2.2. Applied to vessels using otter bottom trawls (OTB) in Subarea 7

Vessel typology using technical characteristics and evolution of average LPUE for each cluster – otter bottom trawls (OTB)

Implementation of Agglomerative Hierarchical Clustering (AHC) on the technical characteristics accounting for the variability of LPUE (vessel length, gauge and power engine) allows distinguishing three clusters (figure 11; characteristics displayed in Table 7).

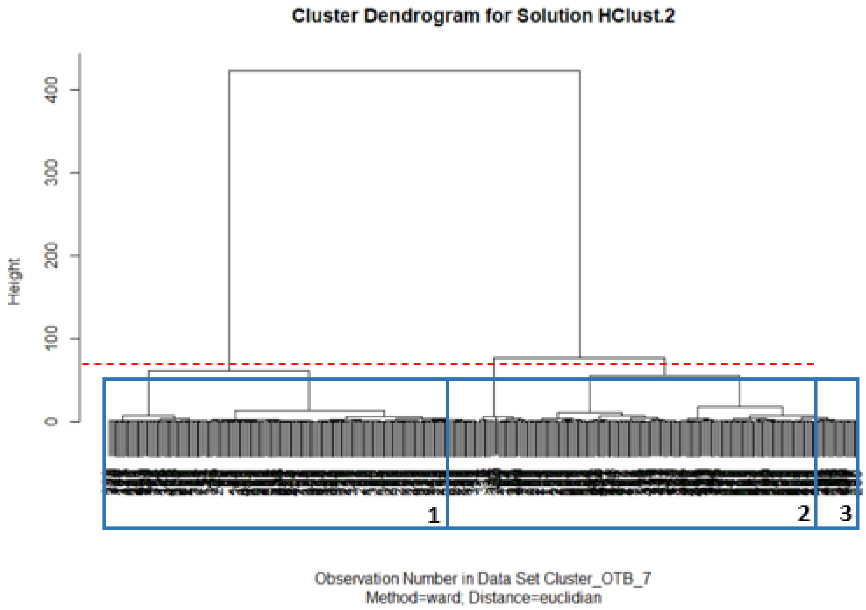

Figure 11: AHC of vessels using OTB in Subarea 7 according to their technical characteristics – vessel length, gauge and engine power (standardized) (red line: visual cut)

Table 7: Values of technical characteristics per cluster for vessels using OTB in Subarea 7

Cluster		Vessel length (m)			Gauge (grt)			Engine power (kW)		
Code	Number	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
1	203	9.00	12.5	17.6	4	27	92	71	177	350
2	27	28.4	33.4	38.0	179	271	453	459	625	883
3	181	17.5	22.5	26.1	83	146	226	305	463	738
Total	411									

For each candidate cluster, changes in landing average calculated by month and by year are shown in Figure 12. The three clusters display highly variable activity. Cluster 1 shows a low level of CPUE, as does Cluster 2, with additional breaks in the data series from 2013 onwards. Cluster 3 shows low activity, generally around the months of April, May and June.

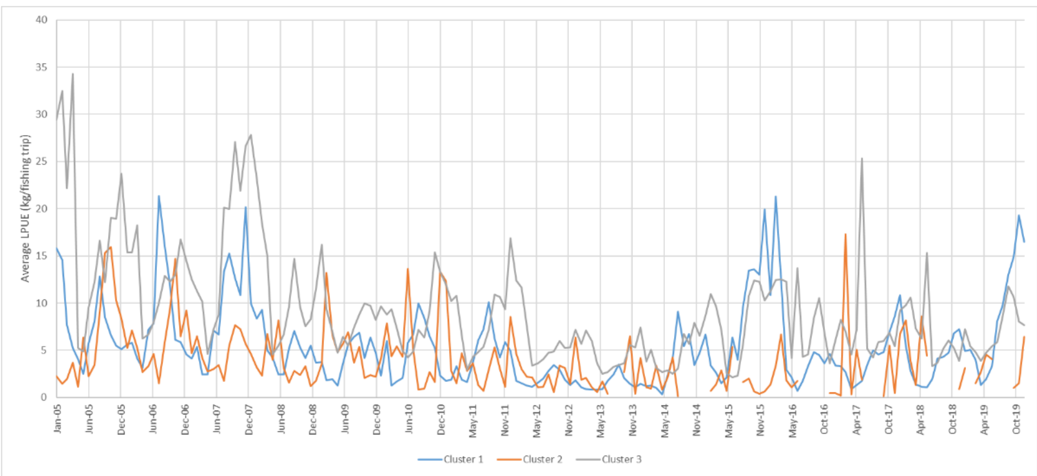

Figure 12: Average LPUEs of striped red mullet per cluster of vessels using OTB in Subarea 7

The catches distribution by statistical rectangle for Cluster 3 over the period 2005-2019 presents a concentration of catches in 7E, with four rectangles accounting for 67% of catches (Figure 13). 37% of catches are even located on the eastern border of the mur-west stock. Under these conditions, the indicator that could be constructed from this fleet does not seem to us to adequately reflect the stock under consideration (mur-west). An interaction with the mur.27.3a47d stock is likely.

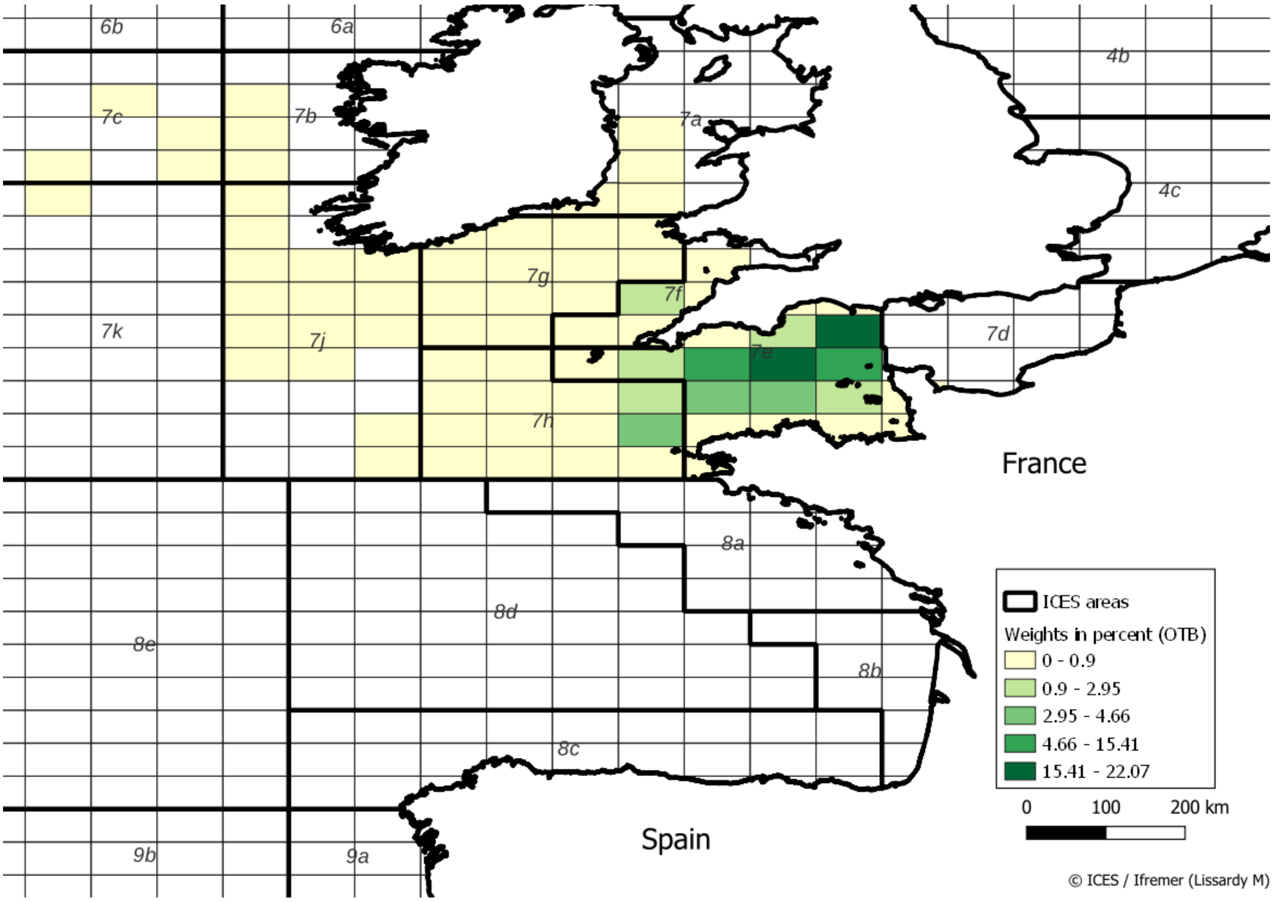

Figure 13: Distribution (in percentages) of trawl catches (OTB) - cluster 3 - between 2005 and 2019 in Subarea 7

Summary
No indicator of striped red mullet abundance from vessels using bottom otter trawls in Subarea 7 is proposed. In addition, the Brexit has repercussions on the activity both in terms of the number of licenses and access to specific statistical rectangles. This fleet is too heavily impacted by regulatory aspects to be retained as a reference fleet.

2.3. Applied to vessels using set gillnet (GNS) in Subarea 7

Vessel typology using technical characteristics and evolution of average LPUE for each cluster –set gillnets (GNS)

Implementation of Agglomerative Hierarchical Clustering (AHC) on the technical characteristics accounting for the variability of LPUE (vessel length and gauge) allows distinguishing three clusters (Figure 14; characteristics displayed in Table 8).

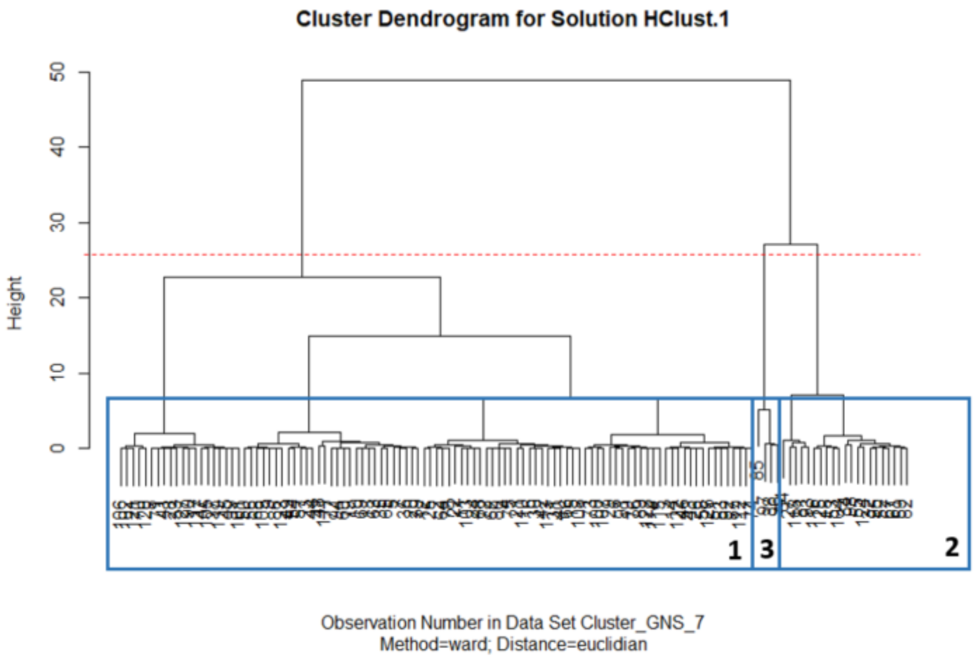

Figure 14: AHC of vessels using GNS in Subarea 7 according to their technical characteristics – vessel length and gauge (standardized) (red line: visual cut)

Table 8: Values of technical characteristics per cluster for vessels using GNS in Subarea 7

Cluster		Vessel length (m)			Gauge (grt)			Engine power (kW)		
Code	Number	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
1	103	5.2	7.8	10.2	0.5	3.8	8.6	7	72	177
2	21	10.0	11.2	13.1	7.3	13.4	31.0	61	141	275
3	4	15.4	16.8	19.4	59.4	72.6	105.0	191	272	336
Total	128									

For each candidate cluster, changes in landing average calculated by month and by year are shown in Figure 15. Clusters 1 and 2 display relatively similar activity from 2015 onwards, while at the start of the period, Cluster 1 is marked by occasionally high levels. There is almost no data for cluster 3.

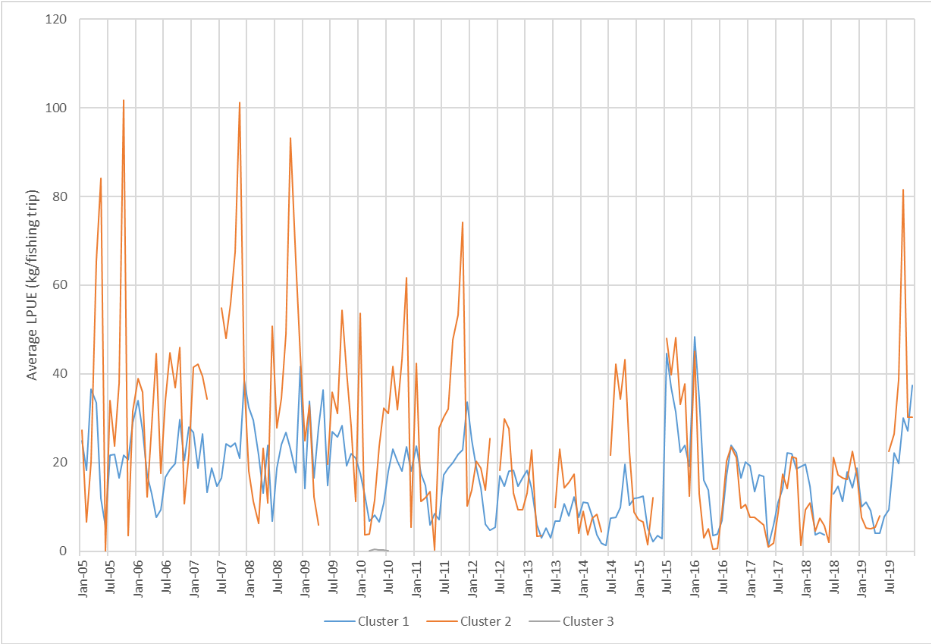

Figure 15: Average LPUEs of striped red mullet per cluster of vessels using GNS in Subarea 7

The catches distribution by statistical rectangle for Clusters 1 and 2 over the period 2005-2019 presents a concentration of catches in 7E at the Brittany extremity, with three rectangles accounting for 90% of catches (Figure 16). These statistical rectangles extend the statistical rectangles that concentrate a large proportion of the Bay of Biscay's catches.

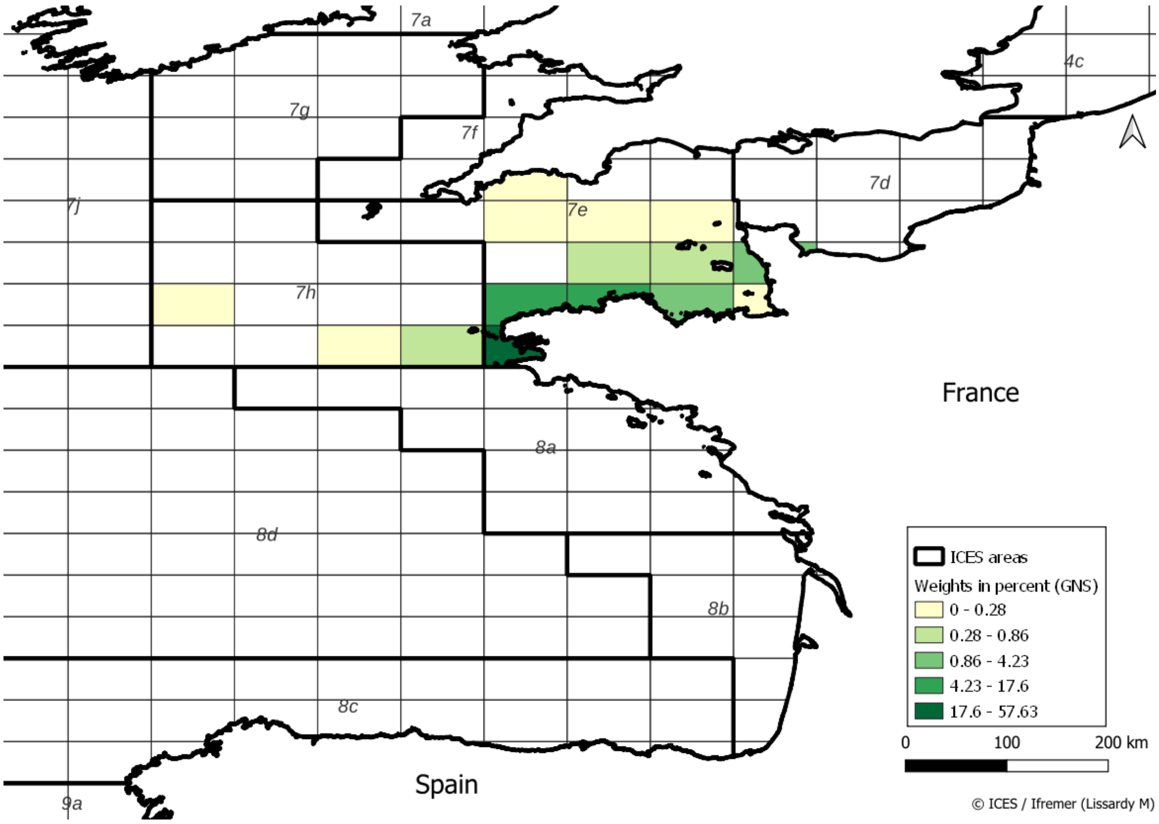

Figure 16: Distribution (in percentages) of gillnetters (GNS) – clusters 1 and 2 - between 2005 and 2019 in Subarea 7

Summary
No indicator of striped red mullet abundance from vessels using gillnets in Subarea 7 is proposed. Instead, it might be worthwhile reworking these data by integrating them with those for Subarea 8, in order to build a "gillnet" indicator for Subareas 7-8.

2.4. Applied to vessels using set gillnet (GNS) in Subareas 7-8

Vessel typology using technical characteristics and evolution of average LPUE for each cluster –set gillnets (GNS)

Implementation of Agglomerative Hierarchical Clustering (AHC) on the technical characteristics accounting for the variability of LPUE (vessel length, gauge and engine power) allows distinguishing three clusters (figure 17; characteristics displayed in Table 9).

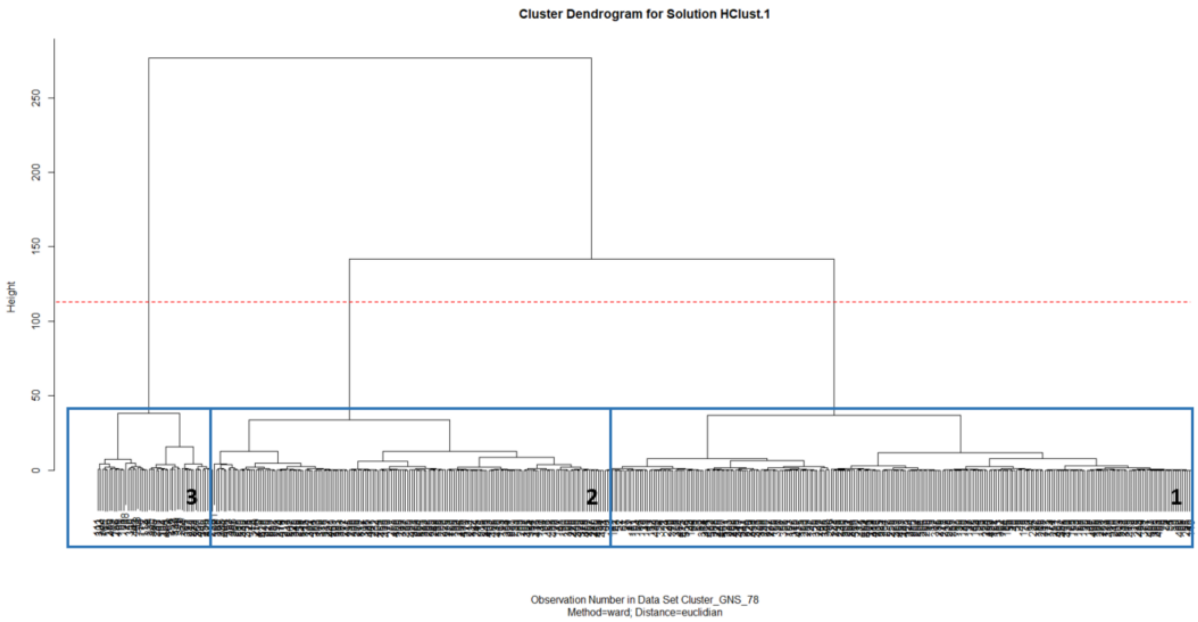

Figure 17: AHC of vessels using GNS in Subareas 7-8 according to their technical characteristics – vessel length, gauge and engine power (standardized) (red line: visual cut)

Table 9: Values of technical characteristics per cluster for vessels using GNS in Subareas 7-8

Cluster		Vessel length (m)			Gauge (grt)			Engine power (kW)		
Code	Number	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
1	253	4.2	7.7	10.2	0.4	3.7	22.3	4	63	124
2	168	7.5	10.8	14.8	2.0	11.4	31.0	70	151	525
3	50	15.1	19.3	30.3	32.4	104.4	195.0	152	310	558
Total	471									

For each candidate cluster, changes in landing average calculated by month and by year are shown in Figure 18. Clusters 1 and 2 show relatively similar activity, with cluster 2 generally showing higher values. Cluster 3 is characterized by breaks in the data series, with high peaks in the first half of the period followed by low levels in the second half. The highest levels are mainly observed around May or June, although this seems less evident in the second half of the period.

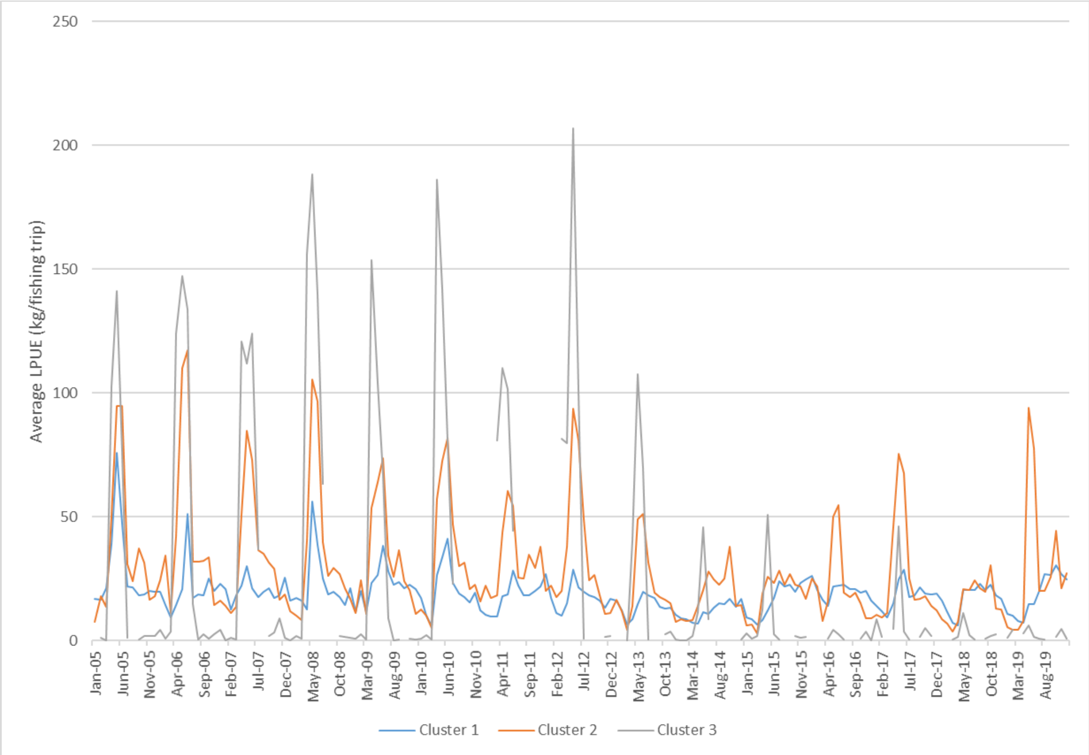

Figure 18: Average LPUEs of striped red mullet per cluster of vessels using GNS in Subareas 7-8

In the Subarea 8 (Figure 19) and for each cluster, the average LPUE is very similar to that observed for the entire zone comprising Subareas 7 and 8.

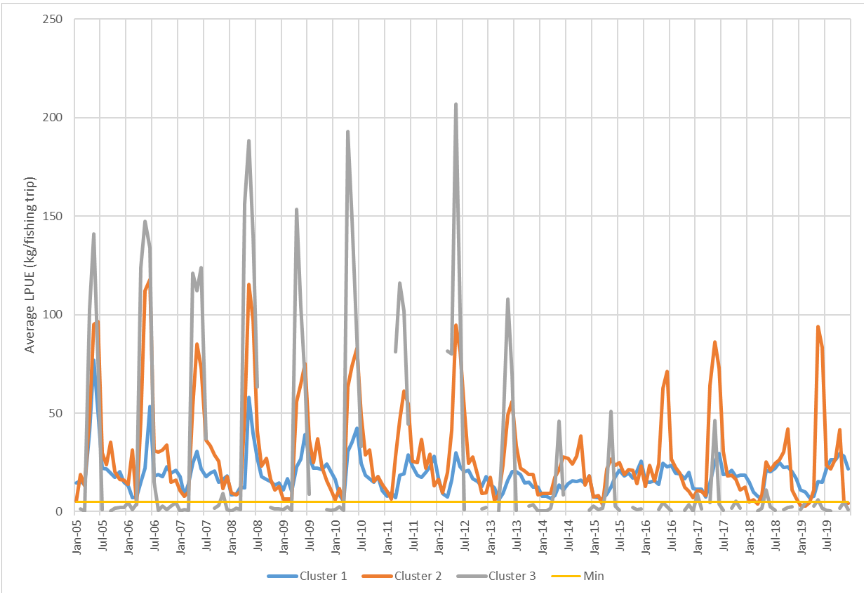

Figure 19: Average LPUEs of striped red mullet per cluster of vessels using GNS in Subarea 8

In the Subarea 7 (Figure 20), and for clusters 1 and 2 overall, seasonality is much less marked than in zone 8. The beginning of the period is marked by strong variations; the second period seems a little more synchronized in terms of seasonality for clusters 1 and 2. There is very little data for cluster 3 in this subarea.

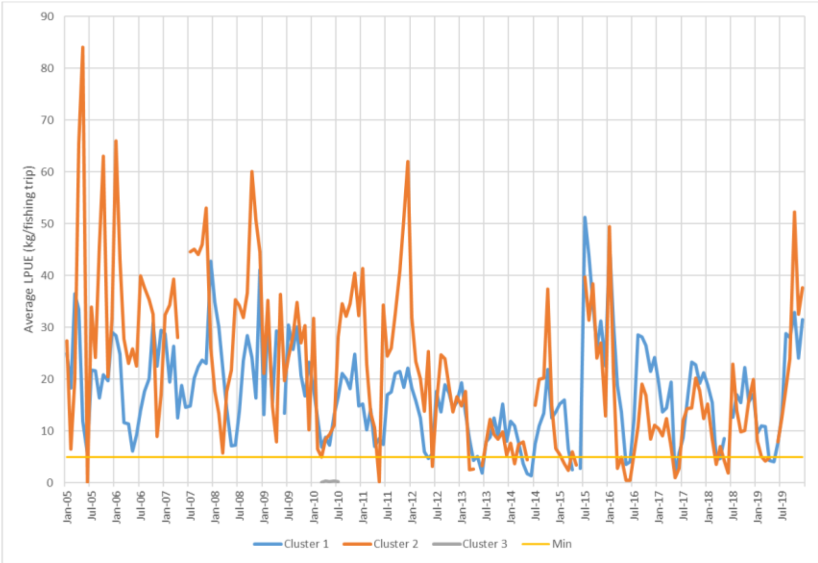

Figure 20: Average LPUEs of striped red mullet per cluster of vessels using GNS in Subarea 7

LPUE levels differ according to the technical characteristics of the vessels. The trend in average catch levels is the most cyclical, with no interruption for clusters 1 and 2 for the entire zone comprising Subareas 7 and 8.

Cluster selection with a multicriteria approach

Ttable 10 summarizes the results following the application of the madatory and optional conditions on the data series.

Table 10: Classification of clusters for GNS in Subareas 7-8

Multi-criteria selection method				
Level of obligation	Vessel typology (technical characteristics)	Cluster 1	Cluster 2	Cluster 3
Mandatory	Sufficient number of vessels (> 10)	X	X	X
	Long data series (> 12 years)	X	X	
	LPUE levels medium to high (> 5 kg/UE) over the period	X (19)	X (29)	(28)
Optional	Stable seasonal signal (both in amplitude and periodicity) during the series	1/3	2/3	
	Activity present in N and S of the zone comprising Subareas 7 and 8	2/3	2/3	
	Moderate seasonal variability	2/3	1/3	
Note		5/9	5/9	
Intra engin		**1**	**1**	

The points system ranks clusters 1 and 2 ex aequo. Compared with the average LPUE of cluster 1 in Subarea 7, those of cluster 2 in Subarea 7 seem to show seasonal trends closer to those observed for Subareas 7-8 as a whole. In addition, discussions in the Reference Fleets WG also highlighted the fact that Cluster 1 comprises small, polyvalent vessels (which are therefore likely to use the line or other gear as well). These factors lead us to choose Cluster 2 for GNS. The vessels in this cluster have an average size of 10.8 m (between 7.5 and 14.8 m), an average gauge of 11.4 grt (between 2.0 and 31.0 grt) and an average power of 151 kW (between 70 and 525 kW). The following analyses therefore refer solely to this cluster.

Study of mesh sizes and seasonal variations in LPUE for Gillnet Cluster 2 (GNS)

Mesh sizes were considered according to several criteria: representativeness of the landing levels, continuity of use and a sufficient number of uses. The mesh size class greater than 90 mm is the most used over the period, although it is mainly the 100 mm mesh size (Figure 21). The other mesh size classes heavily used are 50-59 mm and 60-69 mm.

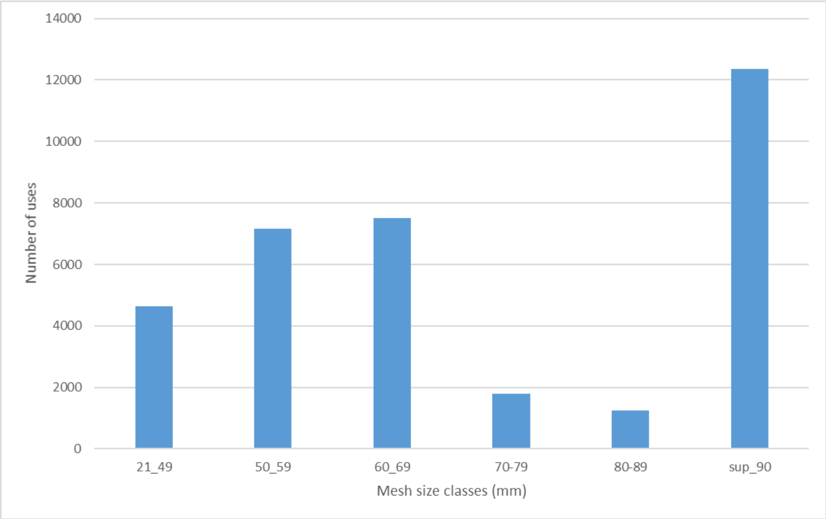

Figure 21: Number of mesh uses between 2005 and 2019 for Cluster 2 - Gillenet (GNS) - Subareas 7-8

Figure 22 shows the monthly evolution of LPUE for the three main meshes of cluster 2 (50-59 mm, 60-69 mm and above 90 mm).

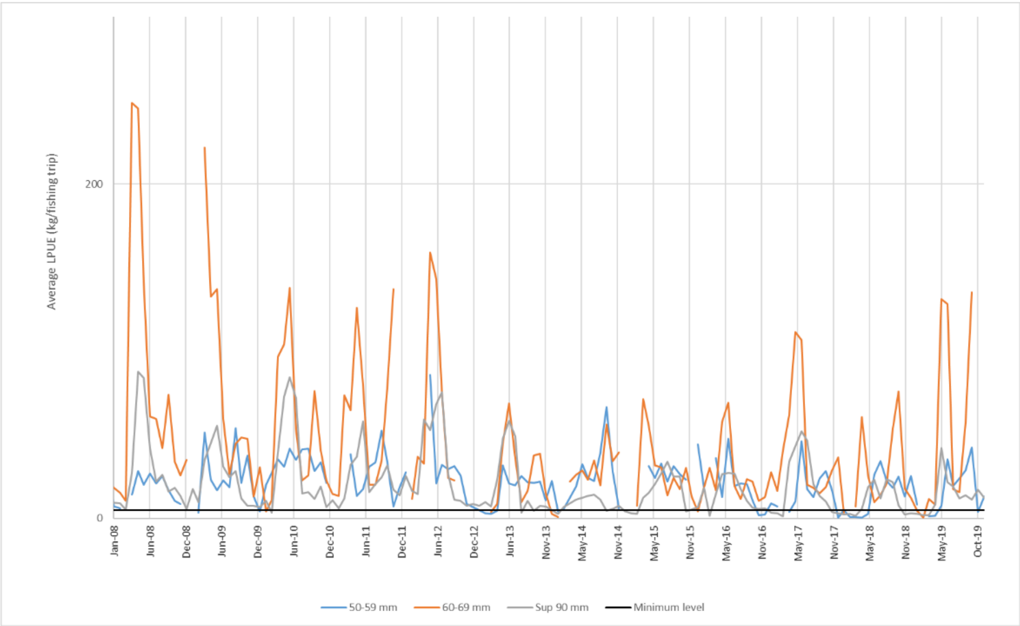

Figure 22: Monthly evolution of LPUE for the main mesh sizes used by Cluster 2 - Gillnet (GNS) - Subareas 7-8

For the criteria considered (Table 11), the three mesh size classes 50 - 59, 60 - 69 mm and above 90 mm are seen as interesting for gillnet. However, the presentation of these results to the WG Reference Fleets highlights the need to handle information on the class above 90 mm with care. In this case, there may be a problem with the accuracy of declarations for striped red mullet. For a single gear declared in the logbook (*e.g.* GNS with 100 mm mesh), some 50 mm mesh nappes targeting striped red mullet may have been used.

Table 11: Mesh size results for Cluster 2 - Gillnet (GNS) - Subareas 7-8

	Proposed mesh size selection(s)		
Métier	Gillnet		
Cluster	2		
Mesh size (mm)	50-59	60-69	Sup 90
Sufficient LPUE level	X	X	X
Availability over a long period	X	X	X
High number of uses	X	X	X
Limited confidence interval		(X)	(X)
Proposed mesh size	Oui	Oui	Oui
Quarterly study	T3	T2	T2

For the 50-59 mm mesh class for GNS cluster 2, LPUE displays low LPUE in the first quarter then higher. The highest levels are observed in September and October. Confidence intervals are particularly wide for many months, particularly in May (Figure 23).

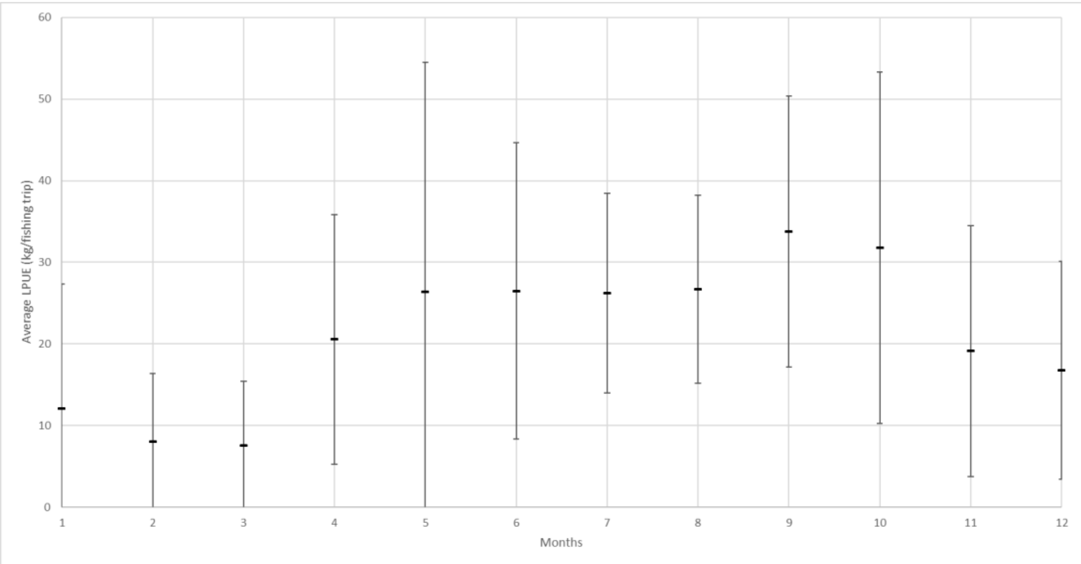

Figure 23: Average LPUE (with CI) per month over the period 2005-2019 for Cluster 2 - Gillnet for mesh size class 50-59 mm – Subareas 7-8

The 60 - 69 mm mesh size class displays high LPUE from April to June. Confidence intervals around the mean are widest between April and June (Figure 24).

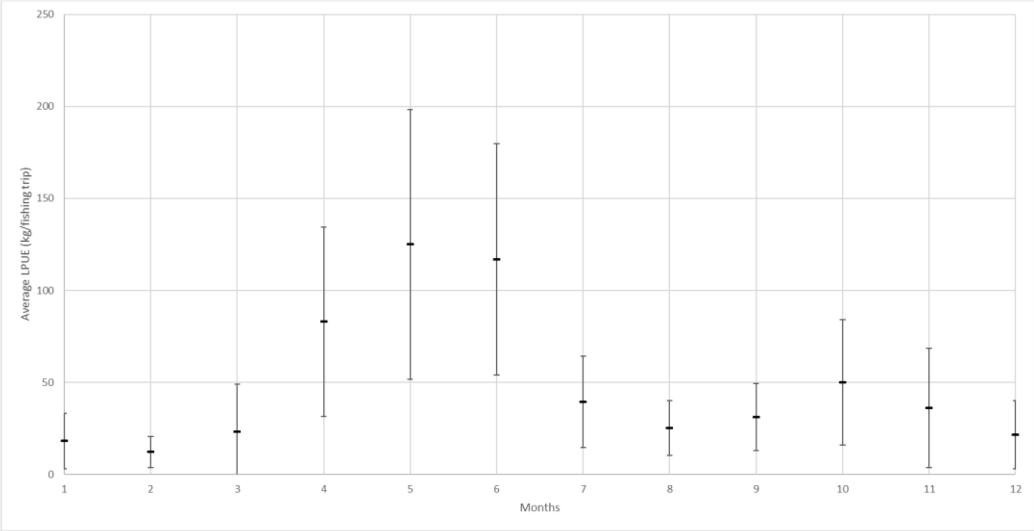

Figure 24: Average LPUE (with CI) per month over the period 2005-2019 for Cluster 2 - Gillnet for mesh size class 60-69 mm – Subareas 7-8

Mesh sizes larger than 90 mm have high LPUE in April, May, June and July. Confidence intervals around the mean are widest between May and July (Figure 25).

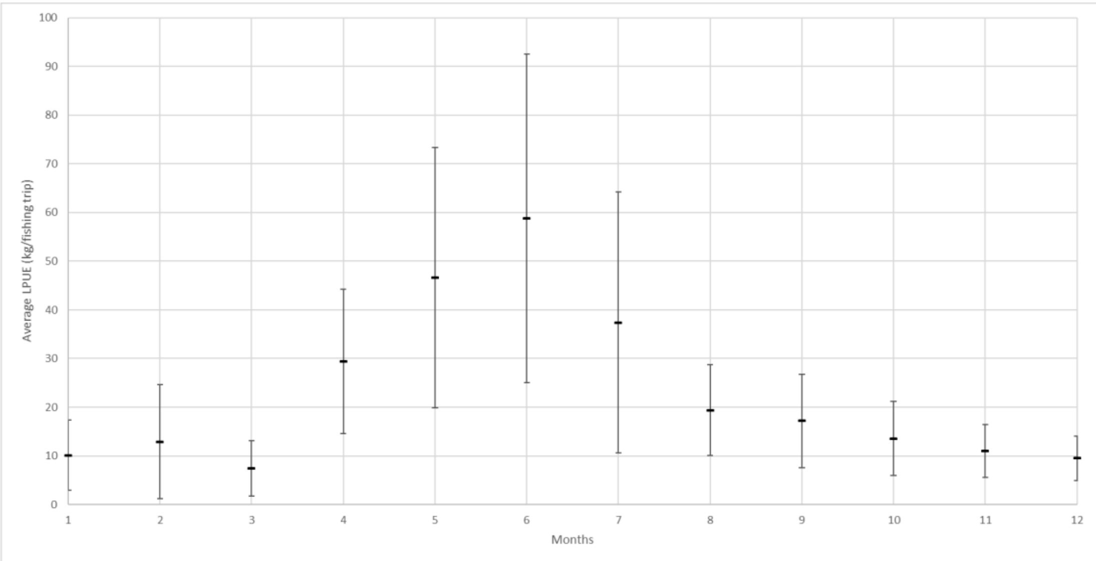

Figure 25: Average LPUE (with CI) per month over the period 2005-2019 for Cluster 2 - Gillnet for mesh size class above 90 mm – Subareas 7-8

For gillnets (GNS), a selection of quarters appears necessary: quarter 3 for the 50 - 59 mm mesh class (quarter 2 having particularly wide confidence intervals), quarter 2 for the 60-69 mm and over 90 mm mesh classes.

Number of uses and LPUE levels per year

For cluster 2 - GNS with a 50-59 mm, 60-69 mm and above 90 mm gear mesh size classes, and for selected quarters, the evolution of their respective uses over time and of the LPUEs for the Subareas 7-8 are considered.

The number of uses of the 50-59 mm mesh class in quarter 3 for GNS cluster 2 remains at a fair level of uses (around 250) up to 2019, then presents a lower level. The level of average LPUE does not display any significant trend over the period (Figure 26).

The number of uses of the 60-69 mm mesh class in quarter 2 for GNS cluster 2 shows a downward trend over the period. The level of average LPUE is marked by low levels in 2014, 2015, 2016 and 2018. The highest levels are observed at the beginning of the period (Figure 27).

The number of uses of the mesh sizes above 90 mm in quarter 2 for GNS cluster 2 also displays a downward trend over the period. The level of average LPUE is again marked by low levels in 2014, 2015, 2016 and 2018. The highest levels are observed at the beginning of the period (Figure 28). It should also be remembered that discussions at the WG Reference Fleets alerted us to the precautions to be taken when using data for this mesh size and for striped red mullet (see p21 above).

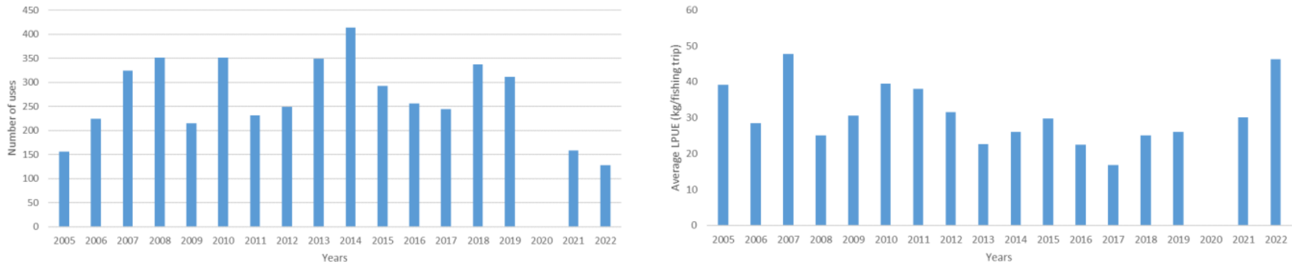

Figure 26: Number of uses and associated average LPUE levels for Subareas 7-8 - Gillnet - cluster 2 - mesh size class 50-59 mm - Quarter 3

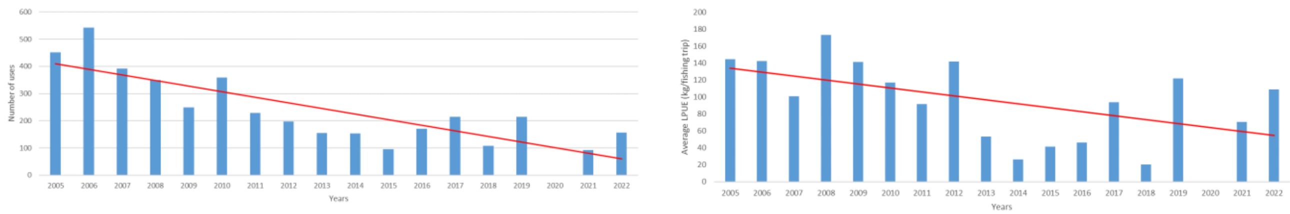

Figure 27: Number of uses and associated average LPUE levels for Subareas 7-8 - Gillnet - cluster 2 - mesh size class 60-69 mm - Quarter 2

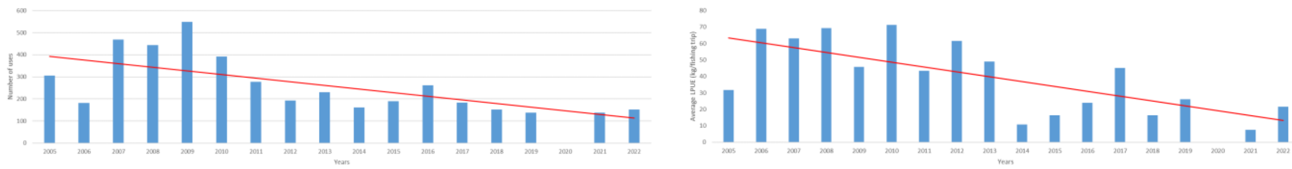

Figure 28: Number of uses and associated average LPUE levels for Subareas 7-8 - Gillnet - cluster 2 - mesh sizes above 90 mm - Quarter 2

Summary

The downward trend in the number of uses observed for all the mesh size classes (recently for 50-59 mm, all along the period for 60-69 mm and above 90 mm), and the above alert for mesh sizes above 90 mm, lead us to be very careful if using a GNS reference fleet. The first one, sub-cluster GNS - cluster 2, using mesh sizes 50-59 mm in quarter 3, may be used if its number of uses increases again.

3. Discussion of the relevance of applying the method to the area comprising Subareas 7 and 8 for Danish seine, trawl and gillnet.

The use of the Danish seine appears too different between Subareas 7 and 8 (vessel length, seasonality, etc.) to be relevant to define a single reference fleet for Subareas 7 and 8. Moreover, in Subarea 8, activity is fairly homogeneously distributed throughout the zone, whereas in Subarea 7, significant activity is found at the eastern limit of the stock's spatial extent.

For vessels using OTB, there is no interest in reworking Subarea 7 data by integrating them with OTB data from Subarea 8 to build a "bottom otter trawl" indicator for Subareas 7-8. The reason for this is that a significant proportion of catches come from the eastern limit of the mur-west stock boundary zone, and interactions with the mur.27.3a47d stock cannot be excluded.

For vessels using GNS, there was an interest in reworking the data by integrating those from Subarea 7 with those from Subarea 8 to build a "gillnet" Subareas 7-8 indicator. The reason for this is that the catches in Subarea 7 are highly localized, and the statistical rectangles in question extend the statistical rectangles that account for a large proportion of the catch in the Bay of Biscay. This work has led us to propose a sub-fleet for GNS in Subareas 7-8 even if attention must be paid to its use.

Acknowledgments

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Versions Sacrois utilisées : V.3.3.11 en janvier 2022 et V.3.3.12 à partir de mars 2023.

Appendixes

Appendix 1

Details of COPIL and GT ACOST reference fleets, with focus on striped red mullet

Date	Designation	Items presented/discussed	Decisions
11/03/2021	COPIL 1	* Scheduled approach for the ACOST project (data, tools, etc.) on striped red mullet * Dedicated WG Reference Fleets announced	
22/11/2021	WG Reference Fleets 1	* Detection of outlier data for trawls, gillnets and Danish seines in Subareas 7 and 8 * OBSMER SDN data in Subareas 7 and 8 * Update of LPUE for OTB and GNS fleets identified during the ROMELIGO project * Application of the "ROMELIGO" method to Danish seines in Subareas 8 and 7, interest in an index for Subareas 7+8?	* For the selected clusters, further analysis of 6 trips identified as outliers for final decision. * Verification of the use of 100 mm mesh in Subarea 8 for Danish seine* * For SDN Subarea 8, look at what the results would be if 70-80 mm meshes were grouped together
09/06/2022	COPIL 2 and WG Reference Fleets 2	* Further data cleaning for the 3 gears * Verification of 100 mm mesh sizes in Subareas 8 for Dansih seine * Application of the ROMELIGO method in Subarea 7 for trawl and gillnet and interest in building an index for Subareas 7 + 8 for trawl and gillnet * First tests of decomposition methods (season, trend) and generalized additive models (GAMs)	* The 6 trips were eliminated from the data set * For the next WG Reference Fleets : - look at what the results would be if the 70-80 mm meshes in zone 8 were grouped together; - test the method on gillnets in Subareas 7+8
23/11/2022	WG Reference Fleets 3	No red mullet element presented - GT dedicated to whiting and pollack	
02/02/2023	WG Reference Fleets 4	No red mullet element presented - GT dedicated to whiting and pollack	
28/03/2023	COPIL 3	* Brief review of work presented at the WG Reference Fleets 1 and 2 regarding striped red mullet * Start of the model-based method (first handling of data with presentation of first descriptive analyses)	
06/06/2023	WG Reference Fleets 5	* Presentation of all that has been done on the selection of reference fleets by data-filtering for discussion and validation. * Presentation of the work in progress regarding LPUE	* Rework the section describing collaboration with professional structures, based on the work of C. Macher and the ICES "Stakeholder

		standardization by modeling, as part of the Master 2 internship on the subject. The aim was to validate the filters used, answer any methodological questions and explain the work still to be done. In both cases, a document was prepared and sent to all participants prior to the WG.	Engagement Strategy" approach. * Redo the analyses leading to the selection of fleets by integrating 2021 and 2022 and see if this would have changed the results. * Addition of regulatory elements provided by professional structures and useful for analysis and interpretation. * Checking of the vessels having worked with the Danish seine in Subarea 8 (the POs concerned send a list of vessels).

Appendix 2

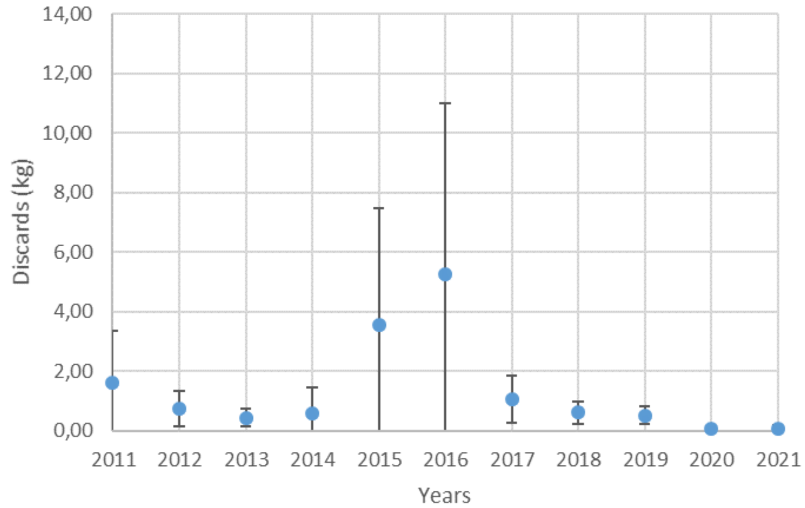
SDN – preliminary stage and step 1 – Figures and tables

Analysis of discards data

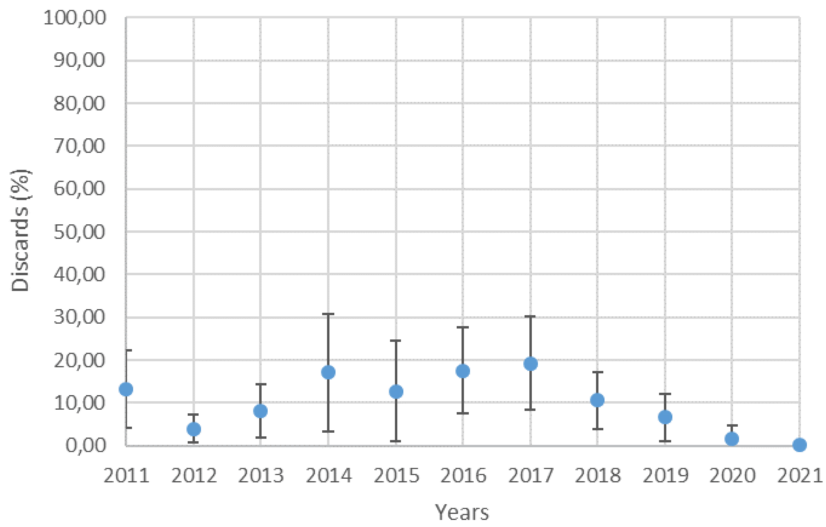
- For Subarea 8

Table 1: Distribution of fishing operations observed by the OBSMER program - SDN - Subarea 8 between 2011 and 2021

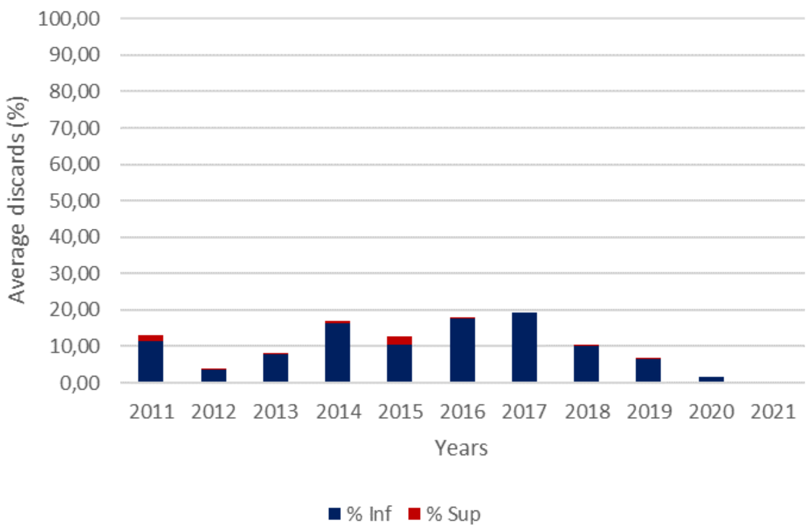
	1	2	3	4	5	6	7	8	9	10	11	12	Total général
2011					16						26		42
2012	3	5	2		5	5	2		2	2	3	1	30
2013	2			5	8	3	2	2	2	4	2	27	57
2014					5	7	2		4	5	2	2	27
2015			3	5		4		2		3			17
2016	2				11		7	7	3	3	5	2	40
2017			7	1	7	3			5		7	3	33
2018	2			4	14		14		3	9	6	1	53
2019	3			15	4	6	2	4		6	6	3	49
2020		8						3					11
2021					6	8							14
Total général	12	13	12	30	76	36	29	18	19	32	57	39	**373**



a)

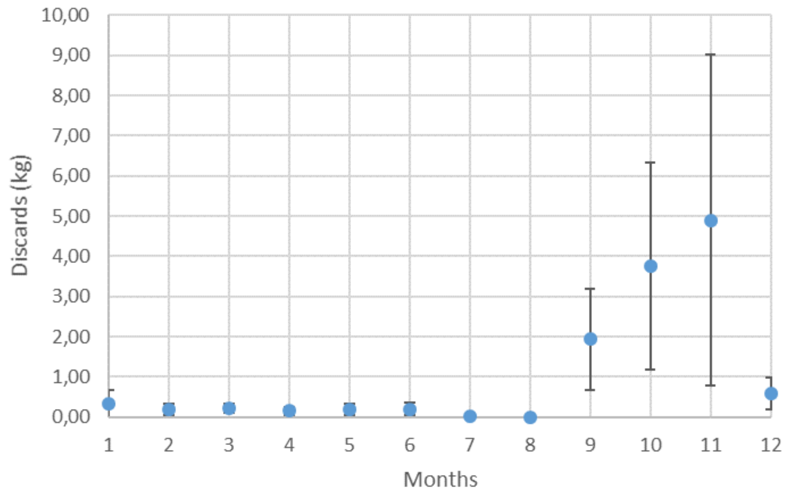


b)



c)

Figure 1: Annual characteristics of discards observed per fishing operation for SDN – Subarea 8: a) mean and standard error in kg; b) mean percentage and its standard error; c) cumulative mean percentage for individuals below and above the minimum commercial weight.



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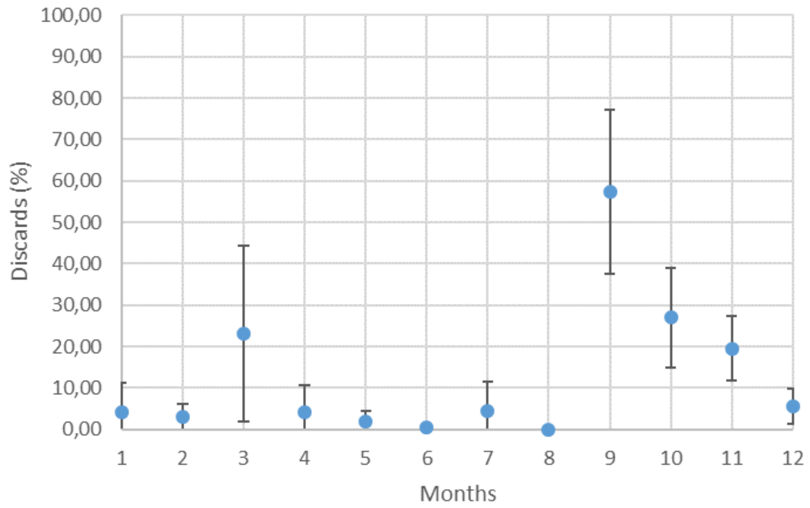

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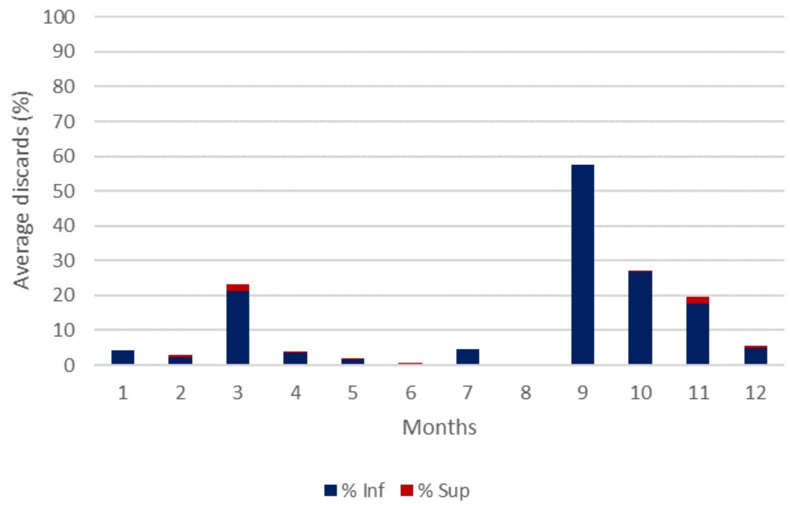


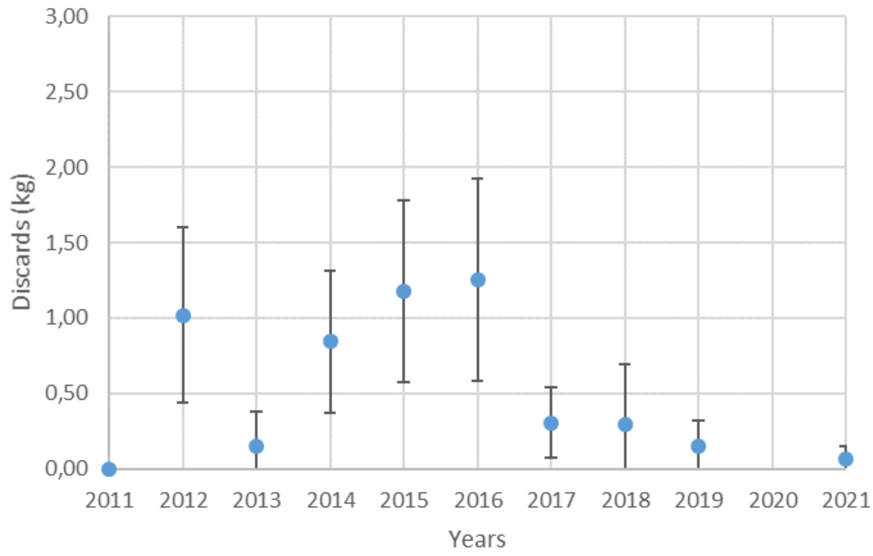
c)

Figure 2: Monthly characteristics of discards observed per fishing operation for SDN – Subarea 8: a) mean and standard error in kg; b) mean percentage and its standard error; c) cumulative mean percentage for individuals below and above the minimum commercial weight.

- For Subarea 7

Table 2: Distribution of fishing operations observed by the OBSMER program - SDN - Subarea 7 between 2011 and 2021

	1	2	3	4	5	6	7	8	9	10	11	12	Total général
2011											15		15
2012							37	4			27		68
2013		1	6			5	8						20
2014			11	9				1		18			39
2015		9		19	4		12			6	21		71
2016	25			17						24			66
2017	11			9							3	12	35
2018							2	7		4			13
2019		6				8			4				18
2020	Pas de données												
2021				2					6				8
Total général	36	16	17	56	4	13	59	12	10	52	66	12	**353**



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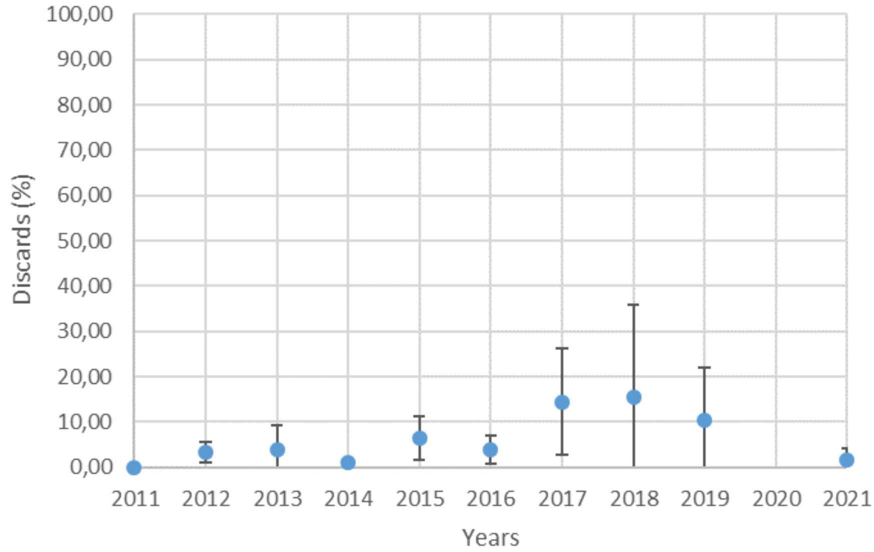
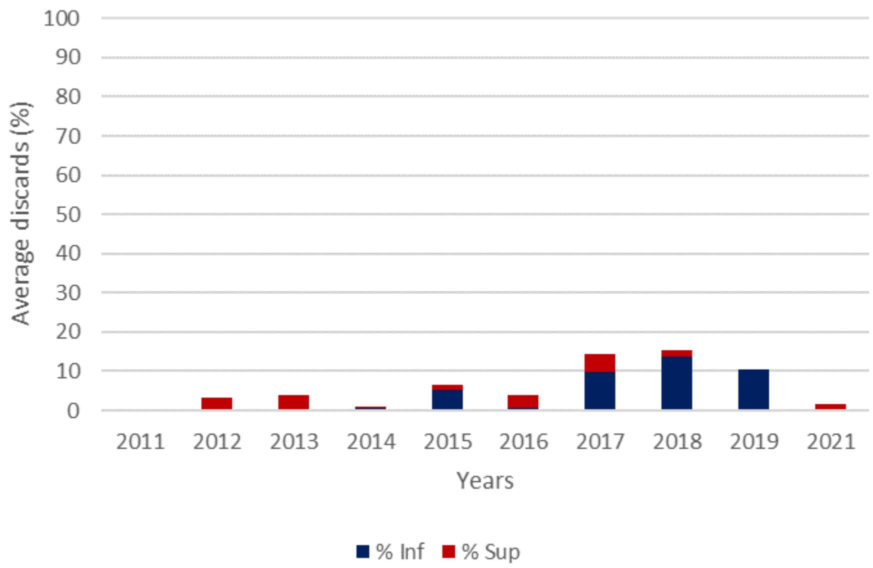
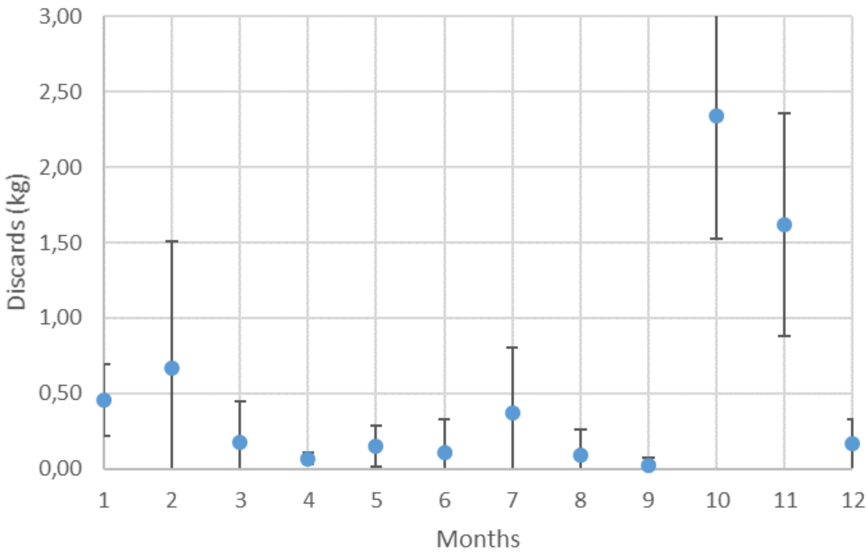


b)

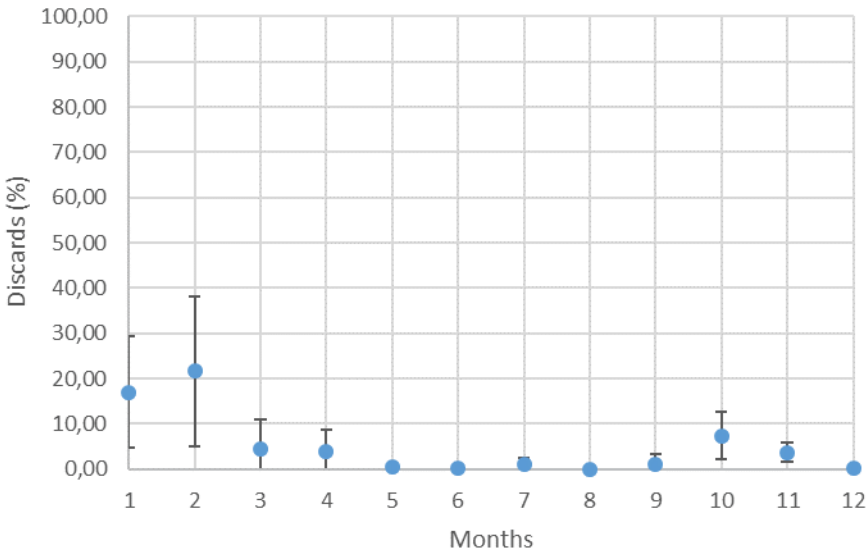


c)

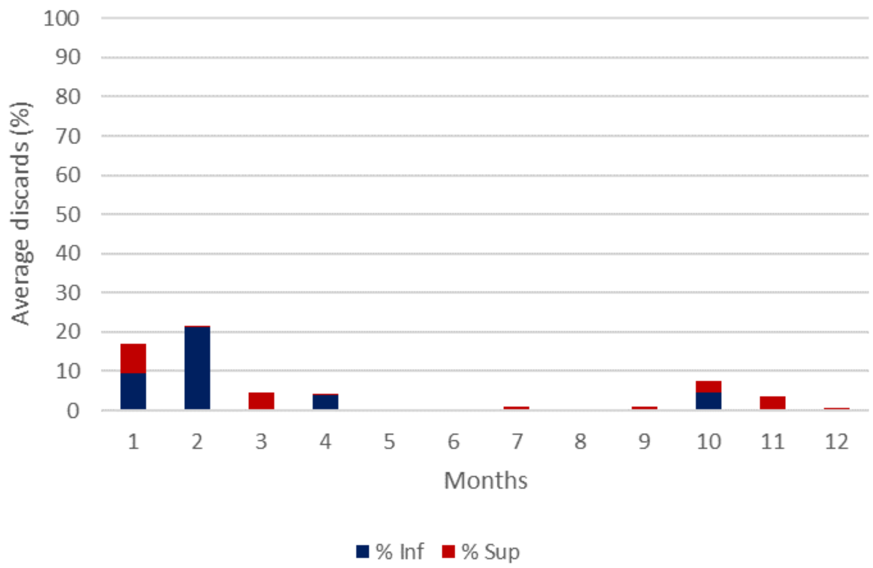
Figure 3: Annual characteristics of discards observed per fishing operation for SDN – Subarea 7: a) mean and standard error in kg; b) mean percentage and its standard error; c) cumulative mean percentage for individuals below and above the minimum commercial weight



a)



b)



c)

Figure 4: Monthly characteristics of discards observed per fishing operation for SDN – Subarea 7: a) mean and standard error in kg; b) mean percentage and its standard error; c) cumulative mean percentage for individuals below and above the minimum commercial weight

Analysis of LPUE data for Subarea 8

Search for linear relationships between variables of interest characterizing LPUE, vessel and gear characteristics, and spatio-temporal factors

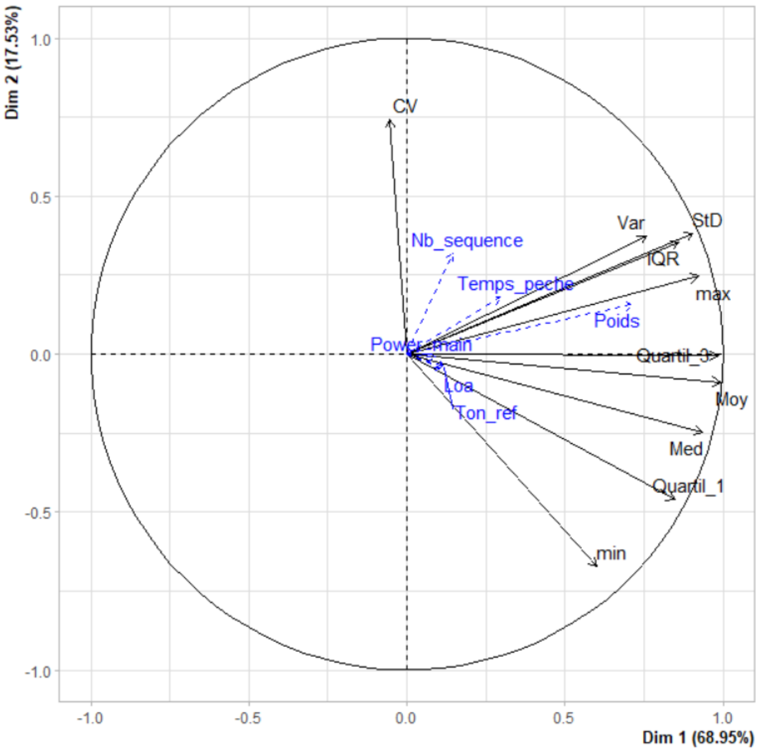


Figure 5: Correlation circle for SDN – Subarea 8 using the first two dimensions

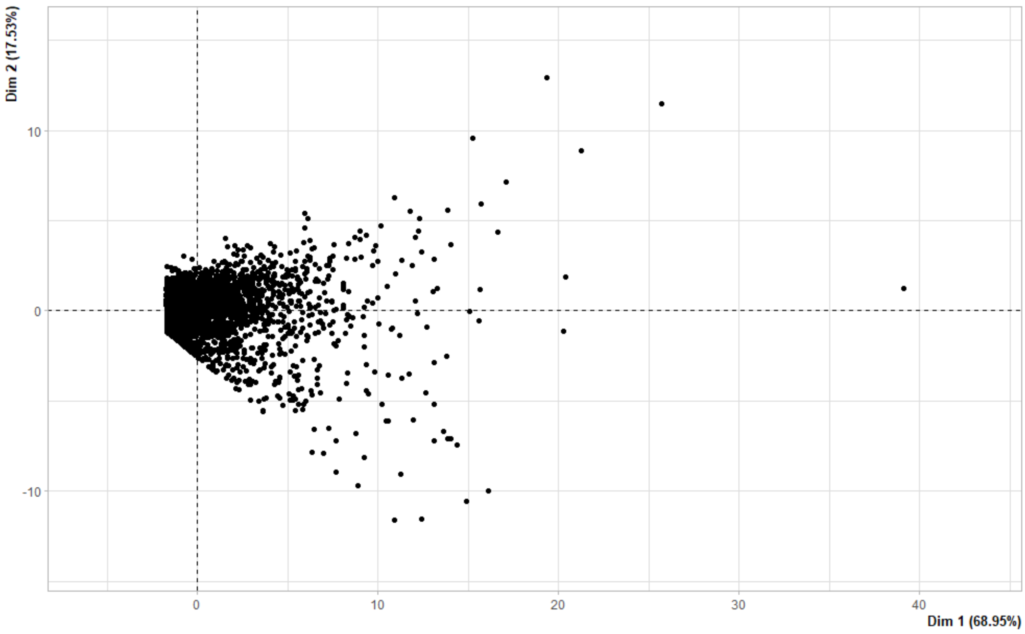


Figure 6: Individuals plot on the first factorial plane of the PCA for the "Danish seine" gear (SDN) - Subarea 8

Figure 7: Barycenter plot of years on the PCA principal factorial plane and associated CAH for the "Danish Seine" gear (SDN) - Subarea 8

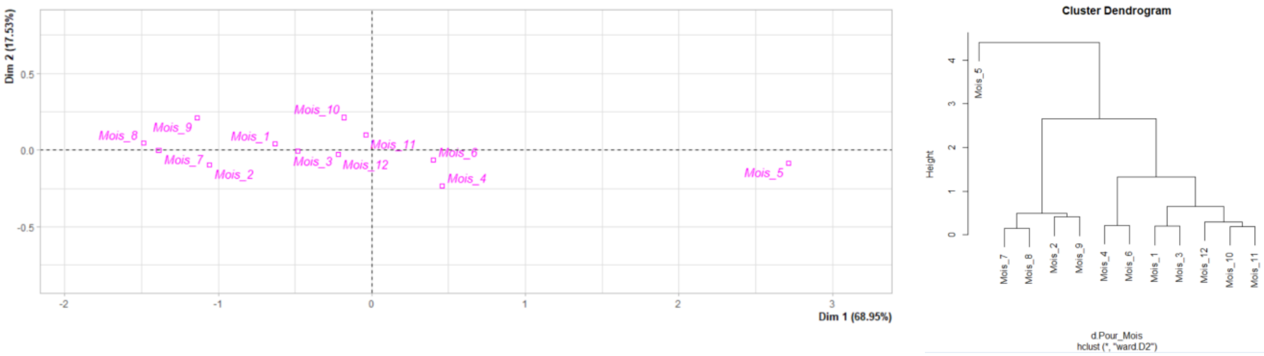


Figure 8 : Barycenter plot of months on the PCA principal factorial plane and associated CAH for the "Danish Seine" gear (SDN) – Subarea 8

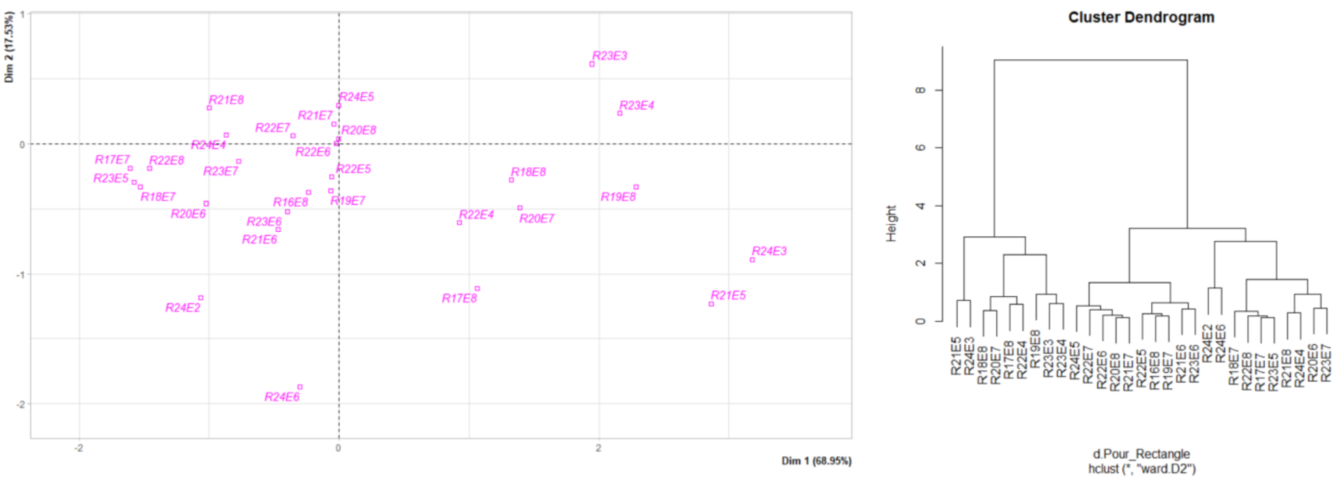


Figure 9: Barycenter plot of statistical rectangles on the PCA principal factorial plane and associated CAH for the "Danish Seine" gear (SDN) - Subarea 8

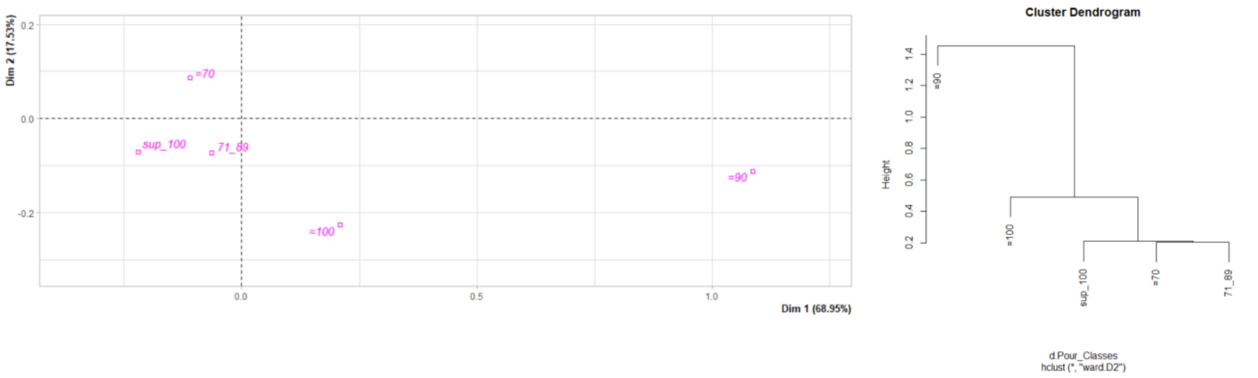
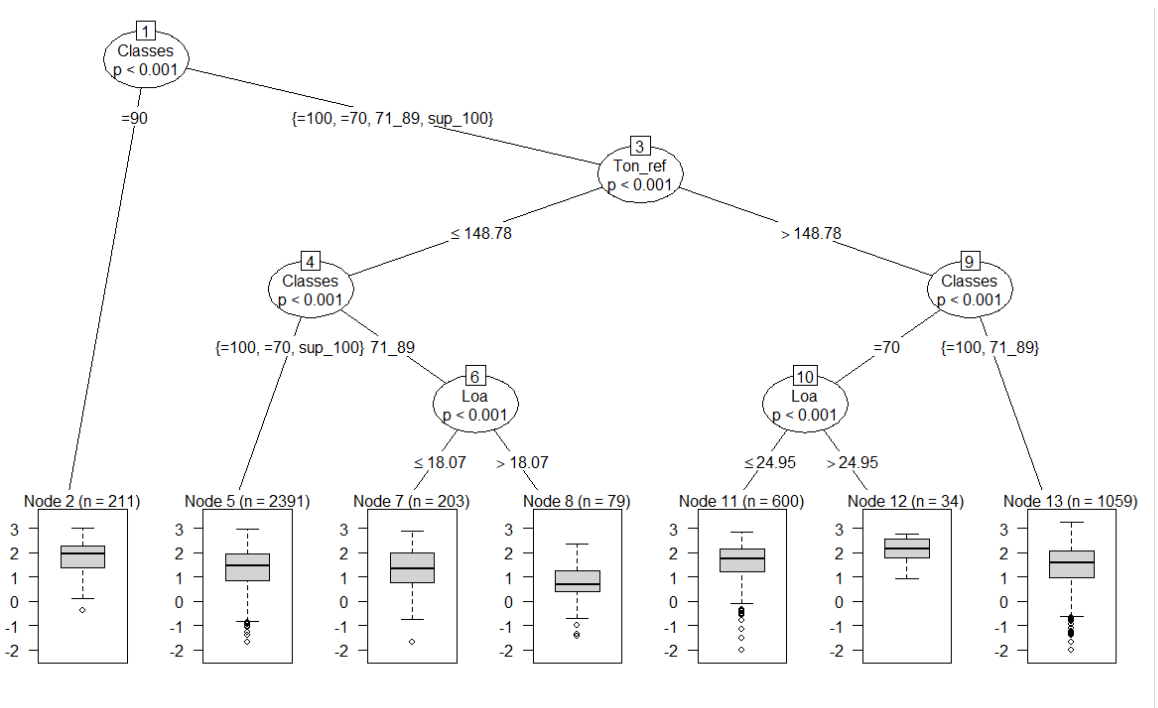


Figure 10: Barycenter plot of mesh size classes on the PCA principal factorial plane and associated CAH for the "Danish Seine" gear (SDN) - Subarea 8

Search for other relationships between variables of interest characterizing LPUE, vessel and gear characteristics, and spatio-temporal factors



Moy	**140**	73	72	19	101	**211**	99
Med	**87**	30	23	5	57	**147**	39
N	211	2391	203	79	600	34	1059

Figure 11: Conditional regression tree on log10Moy (standardized LPUE) with technical characteristics (the values in columns correspond to the values of each node) for SDN - Subarea 8

Analysis of LPUE data for Subarea 8

Search for linear relationships between variables of interest characterizing LPUE, vessel and gear characteristics, and spatio-temporal factors

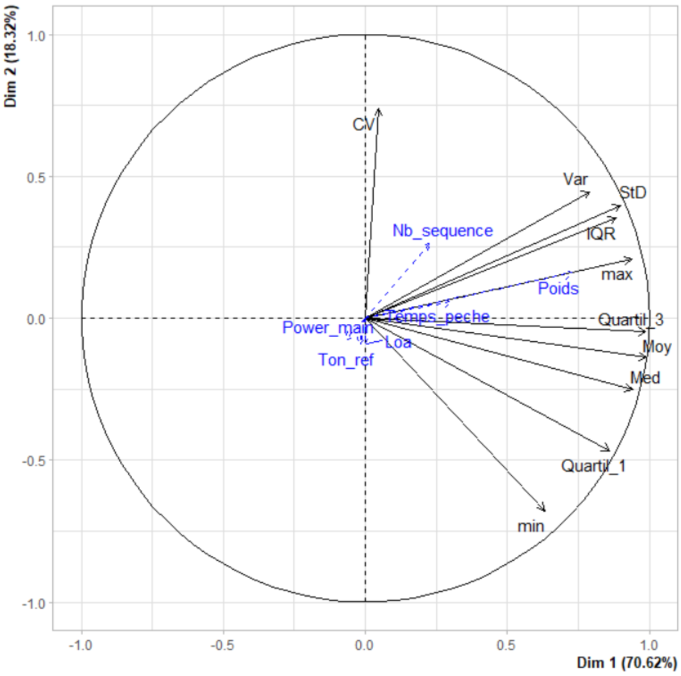


Figure 12: Correlation circle for SDN – Subarea 7 using the first two dimensions

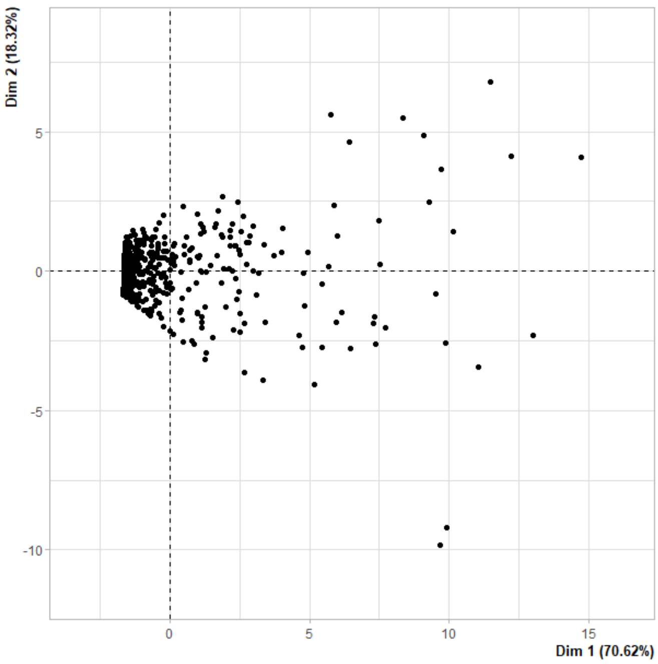


Figure 13: Individuals plot on the first factorial plane of the PCA for the "Danish seine" gear (SDN) - Subarea 7

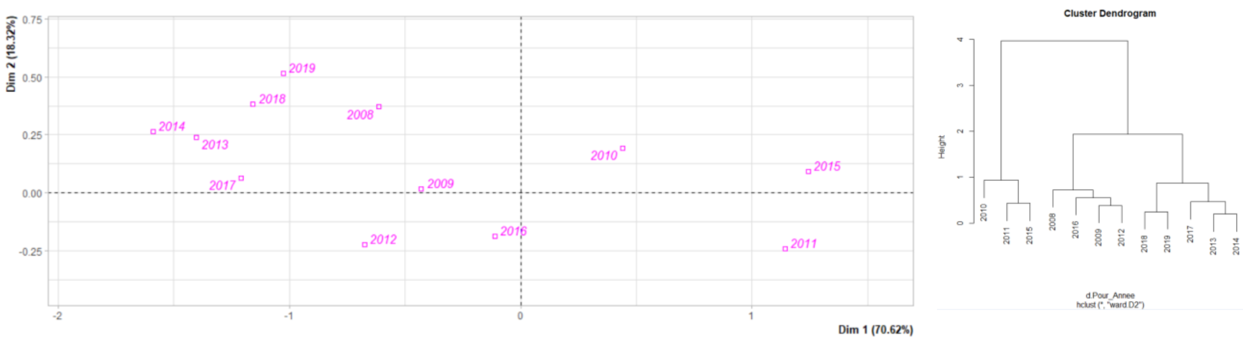


Figure 14: Barycenter plot of years on the PCA principal factorial plane and associated CAH for the "Danish Seine" gear (SDN) - Subarea 7

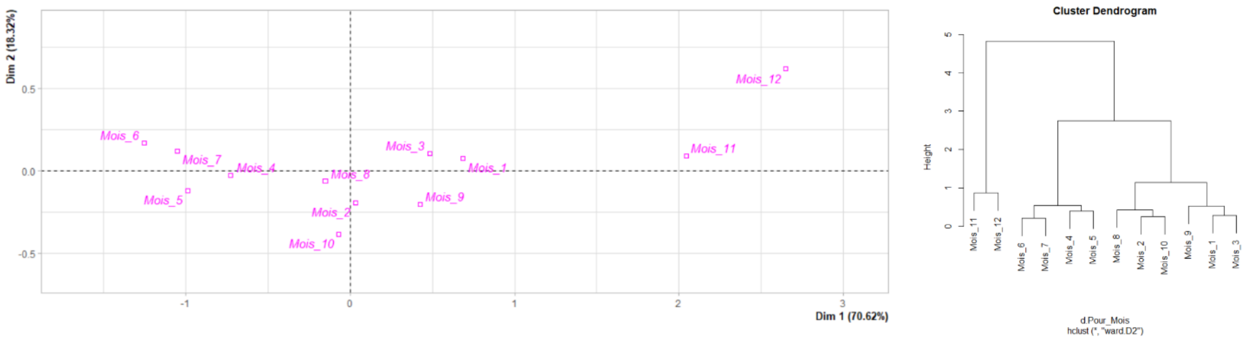


Figure 15: Barycenter plot of months on the PCA principal factorial plane and associated CAH for the "Danish Seine" gear (SDN) - Subarea 7

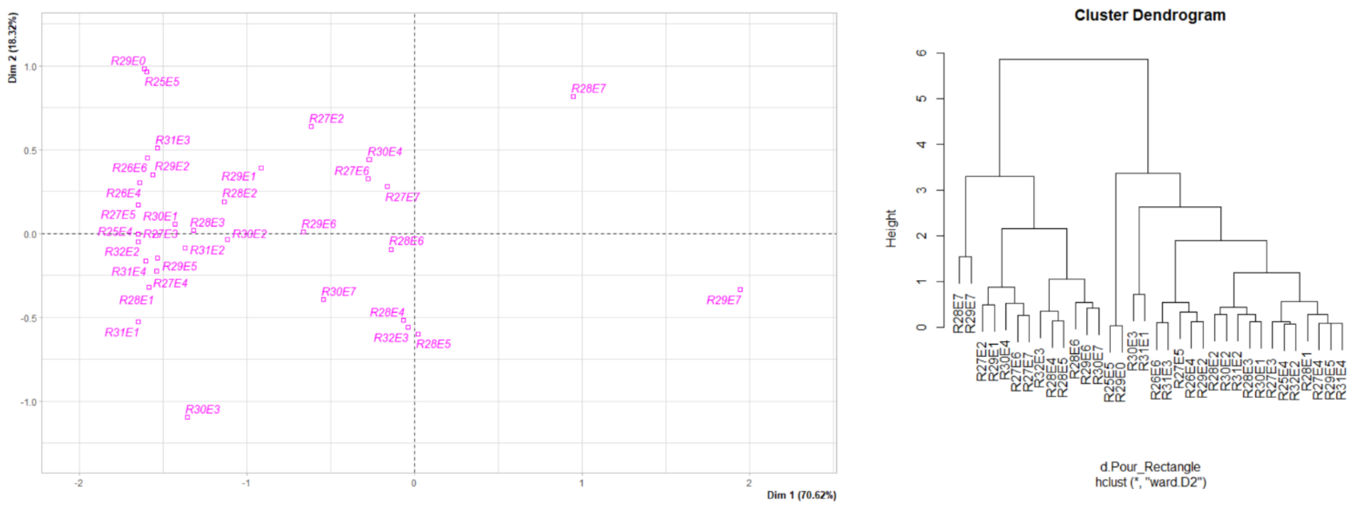


Figure 16: Barycenter plot of statistical rectangles on the PCA principal factorial plane and associated CAH for the "Danish Seine" gear (SDN) - Subarea 7

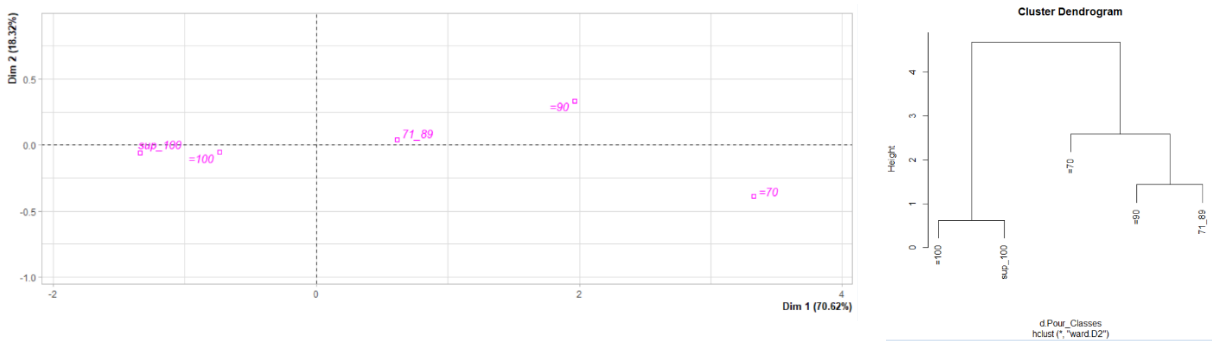
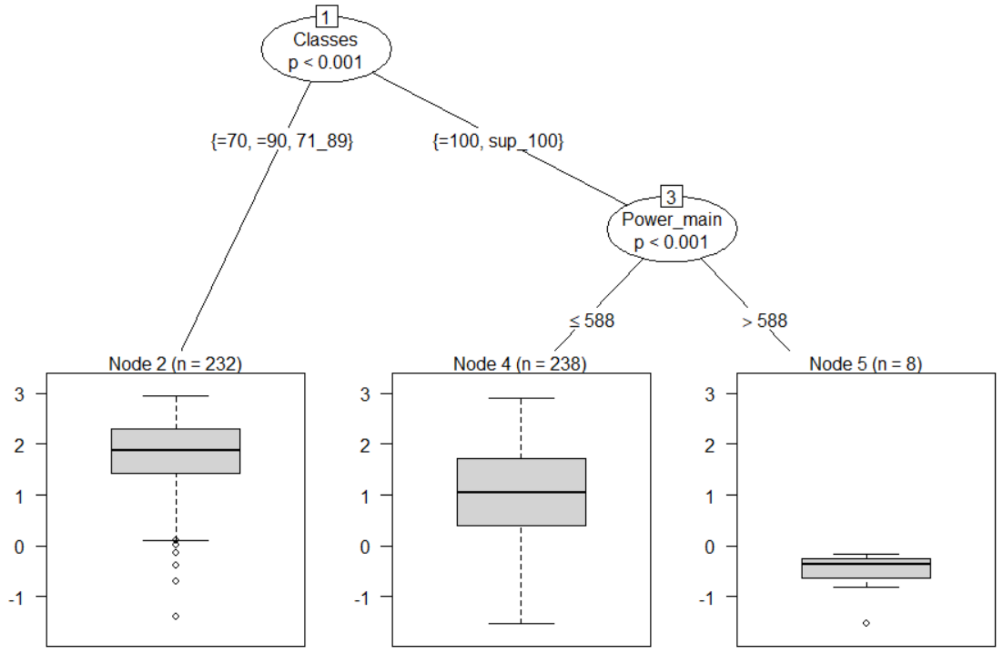


Figure 17: Barycenter plot of mesh size classes on the PCA principal factorial plane and associated CAH for the "Danish Seine" gear (SDN) - Subarea 7

Search for other relationships between variables of interest characterizing LPUE, vessel and gear characteristics, and spatio-temporal factors



Moy	**142**	58	~ 0
Med	**75**	11	~ 0
N	232	238	8

Figure 18: Conditional regression tree on log10Moy (standardized LPUE) with technical characteristics (the values in columns correspond to the values of each node) for SDN - Subarea 7

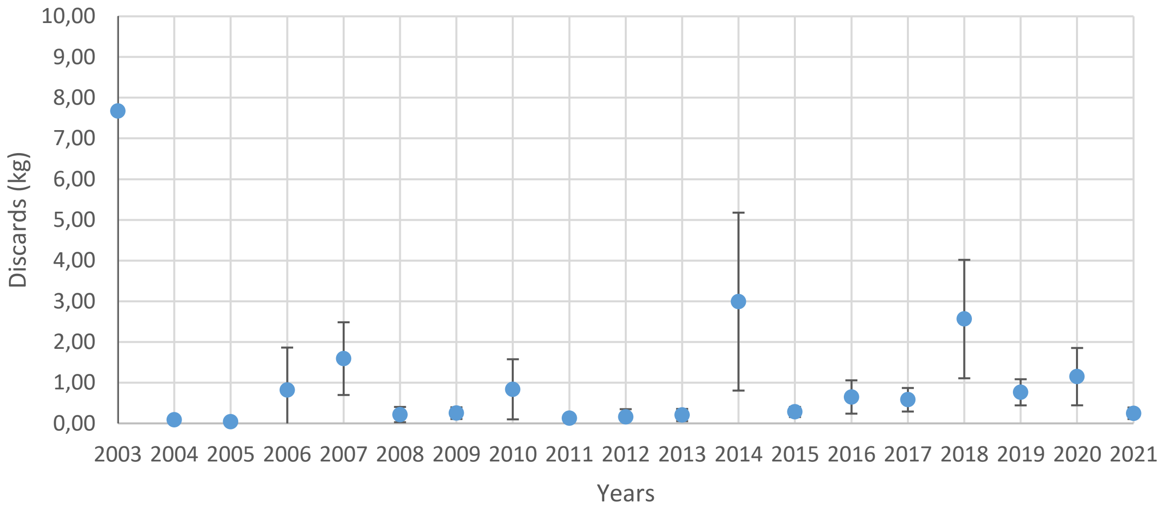
Appendix 3

OTB in Subarea 7 – preliminary stage and step 1 – Figures and tables

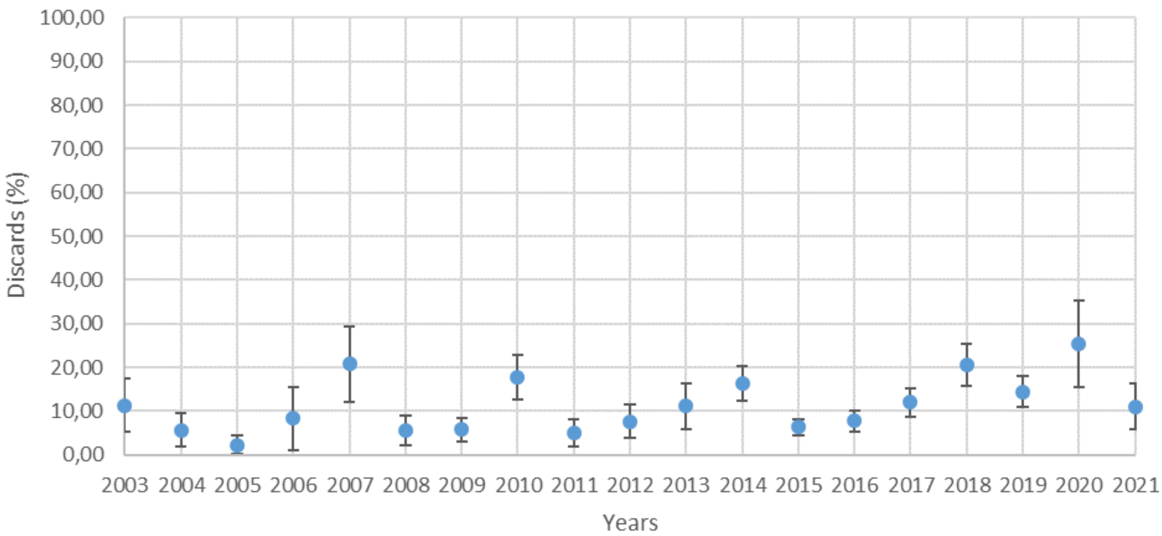
Analysis of discards data

Table 1: Distribution of fishing operations observed by the OBSMER program - OTB - Subarea 7 between 2003 and 2021

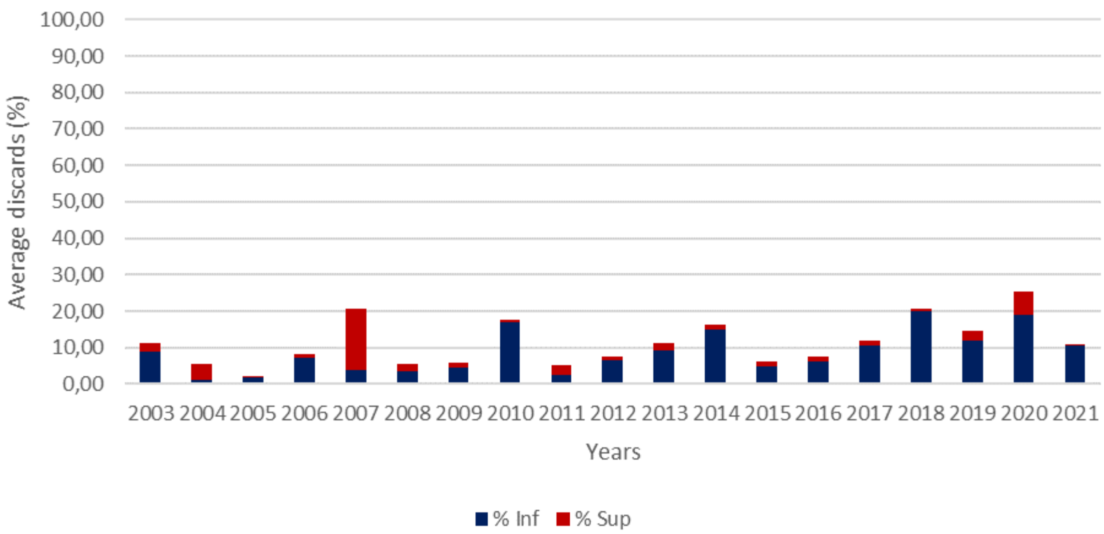
	1	2	3	4	5	6	7	8	9	10	11	12	Total général
2003						2		6	14	27	5		54
2004					2	2	22	46	25	19	14		130
2005					3		25	39	27	33	13	6	146
2006			13	11			6	5		7		4	46
2007					2		9	24		25	11	2	73
2008	3	4		8	1	12	24	10	6	32	14	22	136
2009	14		10	59	46	10	11	13	7	40	24	6	240
2010	19	1		4	13	16	20	31	41	27	5	7	184
2011	2	5	14	19	15	10	26	12	31	22	23	4	183
2012	20	13	12	7	11	7	20	13	34	6	14	3	160
2013		4	3	4	7	8	15	17	20	17	5	5	105
2014	24	8	17	16	13	16	30	19	48	19	23	16	249
2015	10	5	31	20	39	51	43	43	49	46	61	45	443
2016	15	23	15	23	29	35	31	42	41	32	31	44	361
2017	39	33	14	27	13	30	15	23	33	15	11	45	298
2018	7	2	11	3	19	24	11	22	25	37	17	20	198
2019	2	32	26	5	35	15	16	28	55	26	24	19	283
2020	9	16	2				5	4	7		9	8	60
2021	7	14	9	5	7	24	4	12	22				104
Total général	171	160	177	211	255	262	333	409	485	430	304	256	**3453**



a)

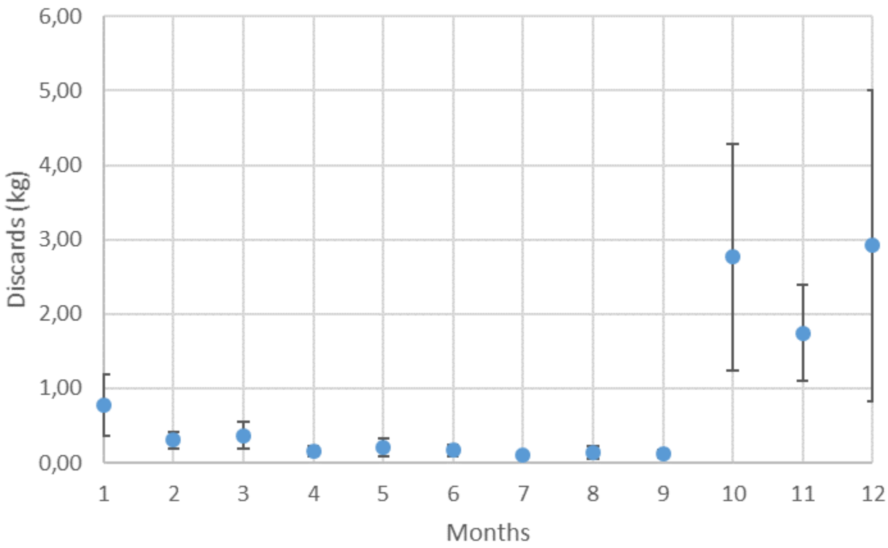


b)

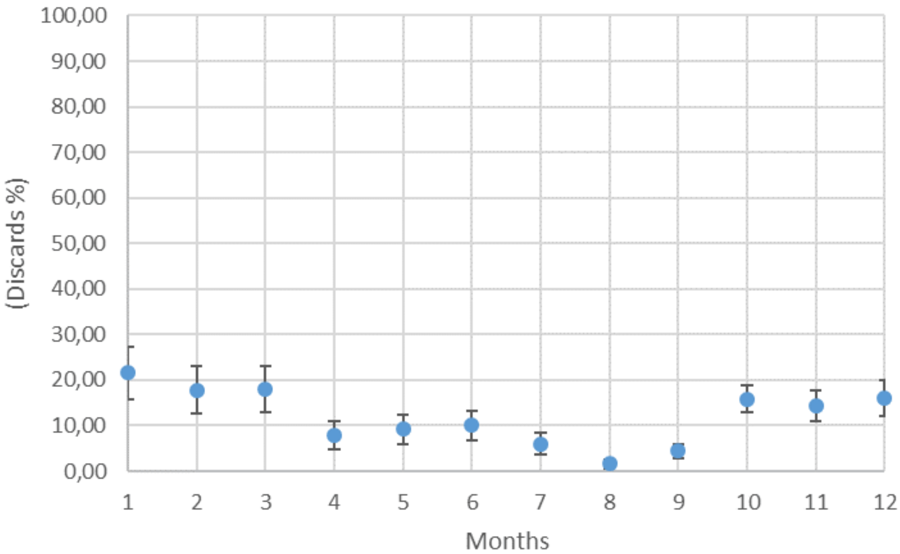


c)

Figure 1: Annual characteristics of discards observed per fishing operation for OTB – Subarea 7: a) mean and standard error in kg; b) mean percentage and its standard error; c) cumulative mean percentage for individuals below and above the minimum commercial weight



a)



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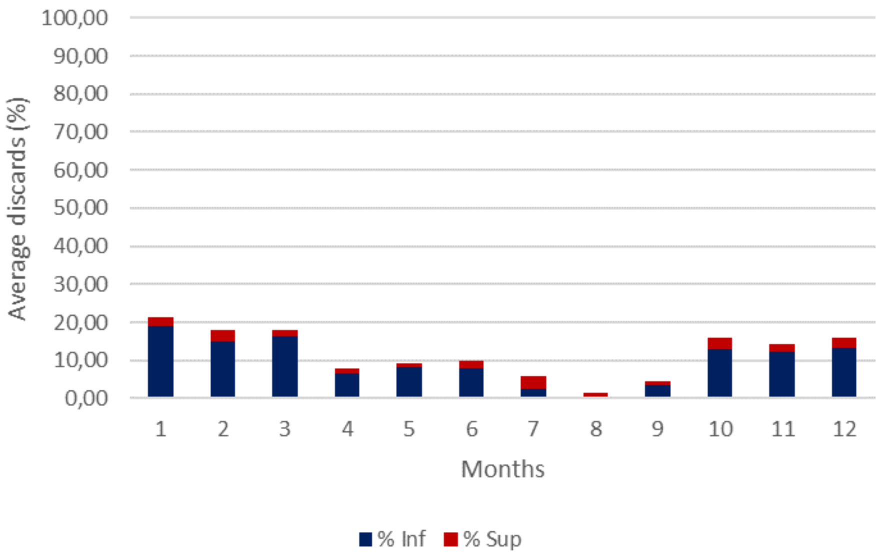


c)

Figure 2: Monthly characteristics of discards observed per fishing operation for OTB – Subarea 7: a) mean and standard error in kg; b) mean percentage and its standard error; c) cumulative mean percentage for individuals below and above the minimum commercial weight

Analysis of LPUE data

Search for linear relationships between variables of interest characterizing LPUE, vessel and gear characteristics, and spatio-temporal factors

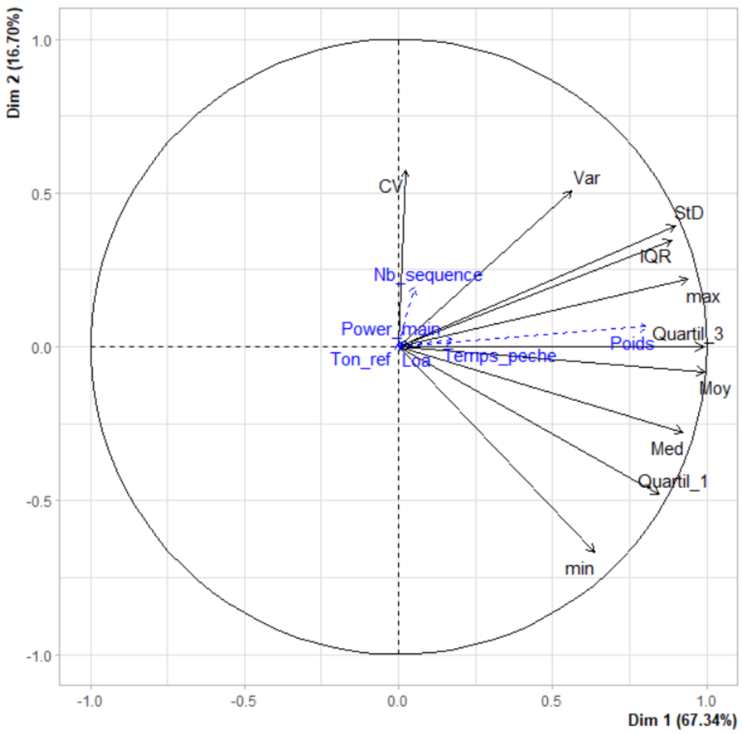


Figure 3: Correlation circle for OTB – Subarea 7 using the first two dimensions

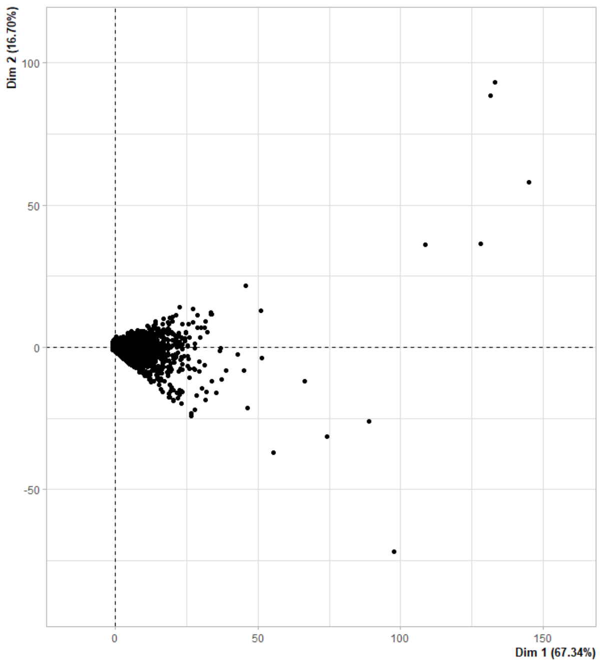


Figure 4: Individuals plot on the first factorial plane of the PCA for the "Bottom otter trawl" gear (OTB) - Subarea 7

Figure 5: Barycenter plot of years on the PCA principal factorial plane and associated CAH for the " Bottom otter trawl " gear (OTB) - Subarea 7

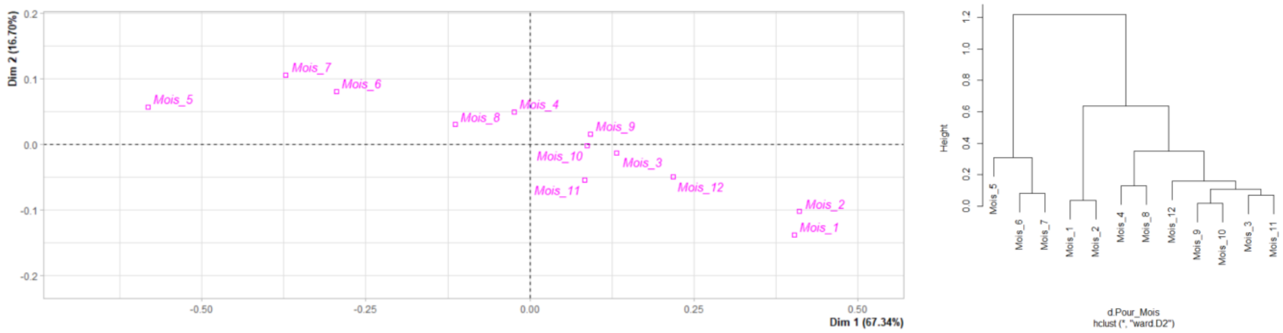


Figure 6: Barycenter plot of months on the PCA principal factorial plane and associated CAH for the " Bottom otter trawl " gear (OTB) - Subarea 7

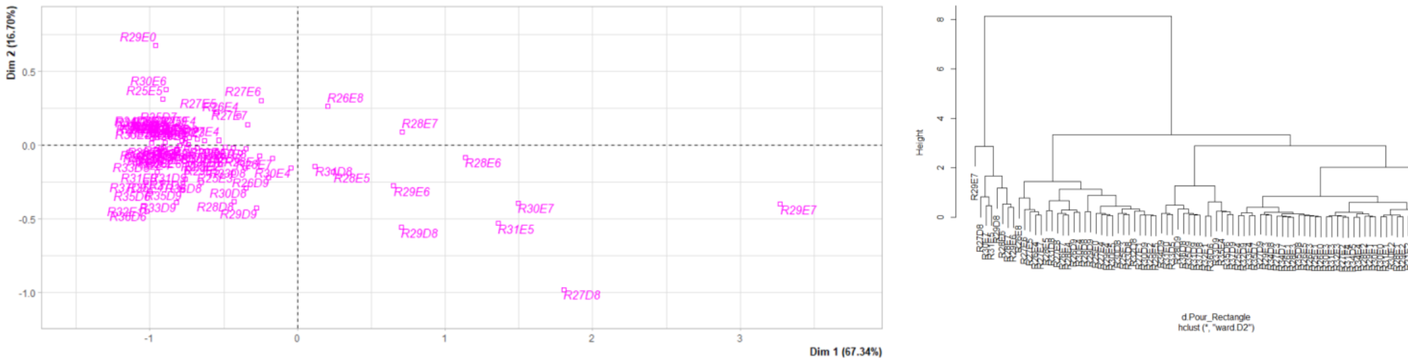


Figure 7: Barycenter plot of statistical rectangles on the PCA principal factorial plane and associated CAH for the " Bottom otter trawl " gear (OTB) - Subarea 7

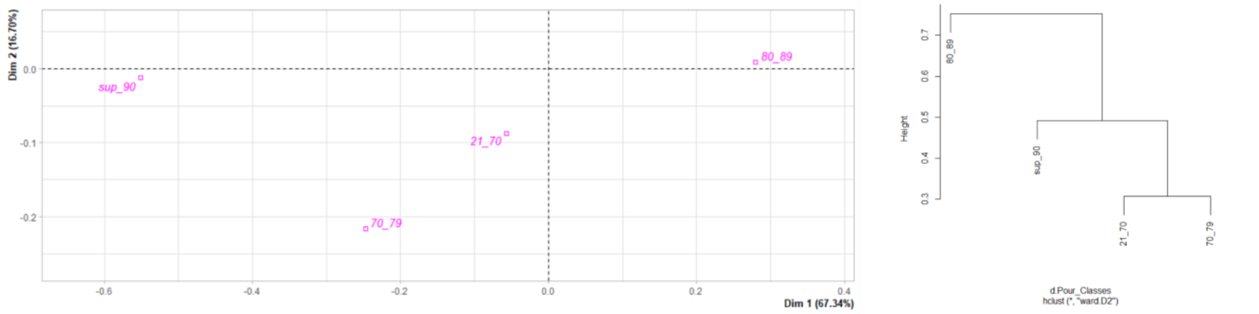
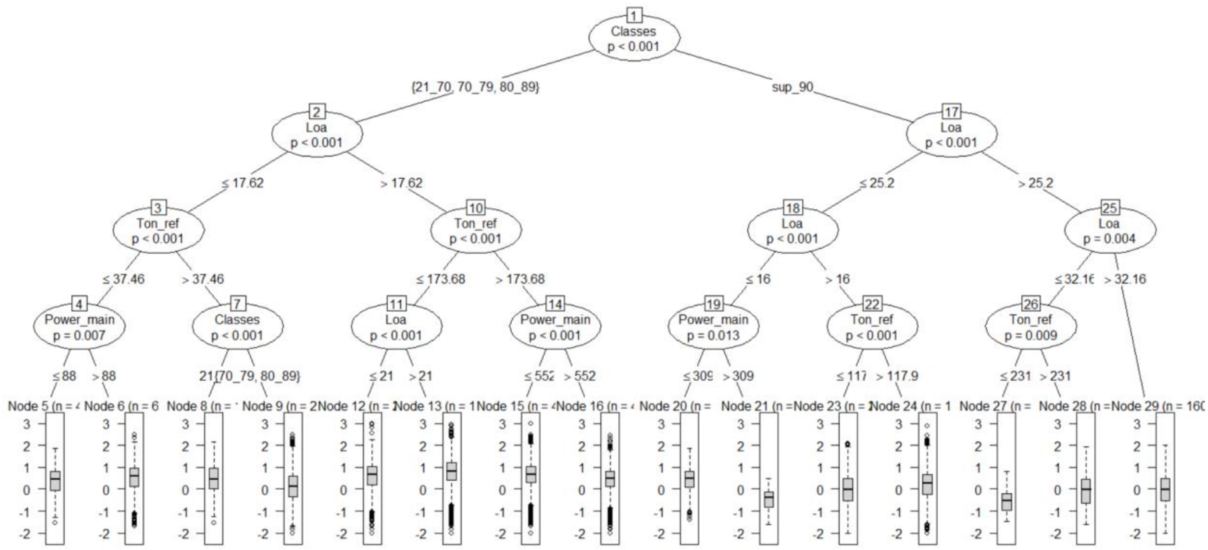


Figure 8: Barycenter plot of mesh size classes on the PCA principal factorial plane and associated CAH for the " Bottom otter trawl " gear (OTB) - Subarea 7

Search for other relationships between variables of interest characterizing LPUE, vessel and gear characteristics, and spatio-temporal factors



Moy	5.6	7.5	8.6	5.6	**11.2**	**15.2**	**11.2**	5.2	5.6	0.6	3.2	4.3	0.6	4.4	3.2
Med	2.8	3.9	2.9	1.3	**4.7**	**6.7**	**4.7**	3.1	3.0	0.4	0.9	1.8	0.3	0.9	0.9
N	412	6118	145	2661	**2570**	**14996**	**4487**	4793	779	13	2321	13084	61	56	1607

Figure 9: Conditional regression tree on log10Moy (standardized LPUE) with technical characteristics (the values in columns correspond to the values of each node) for OTB - Subarea 7

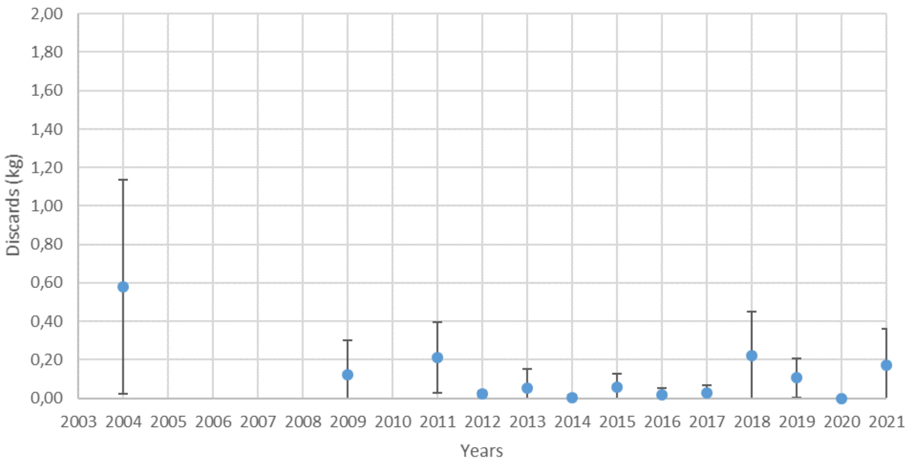
Appendix 4

GNS – preliminary stage and step 1 – Figures and tables

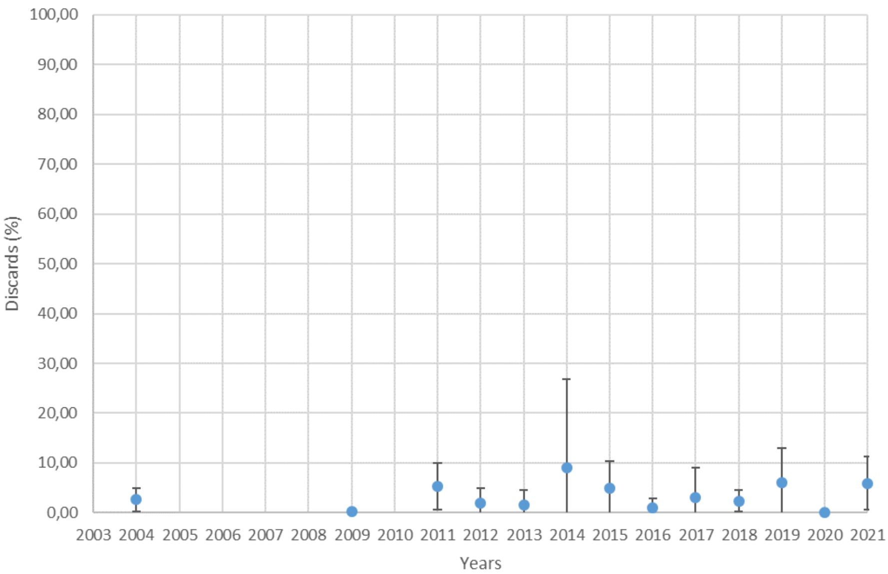
Analysis of discards data

Table 1: Distribution of fishing operations observed by the OBSMER program - GNS - Subarea 7 between 2004 and 2021

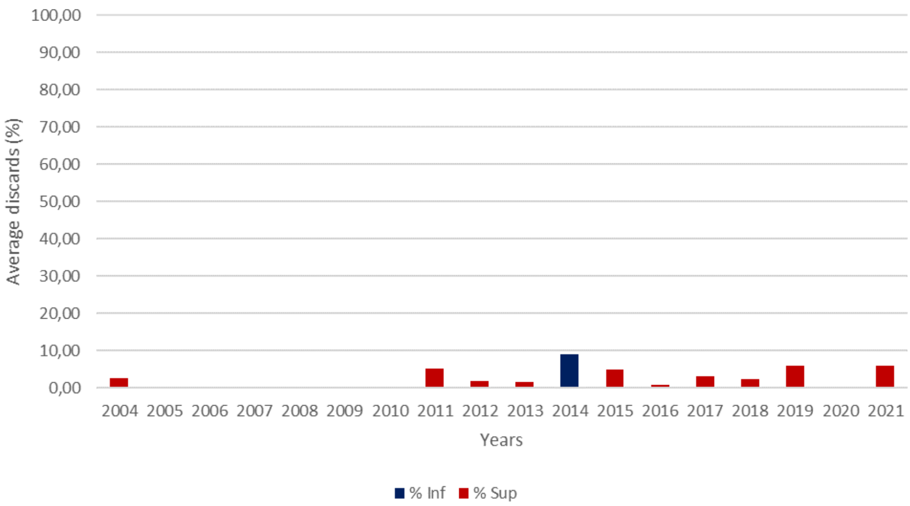
	1	2	3	4	5	6	7	8	9	10	11	12	Total général
2004							9	3				4	16
2007				1									1
2008									1				1
2009								1	2	9			12
2010		1		1									2
2011								4	3	4	9	1	21
2012	6	16	8		1	1	6	12	2	2	10	4	68
2013				2		2	1	5	2		2		14
2014				1			2	2	3	2	1		11
2015	2			1			8		15	16	2	10	54
2016	8	4	6	1				3	2	2	1	6	33
2017	8	4	1		1			7	2	2	9		34
2018	5	4		3			3	6		3	9	1	34
2019		12	2	2			1		9	3	2		31
2020		2					2				10	1	15
2021	1		2				8	17	8				36
Total général	30	43	19	12	2	3	40	60	49	43	55	27	**383**



a)

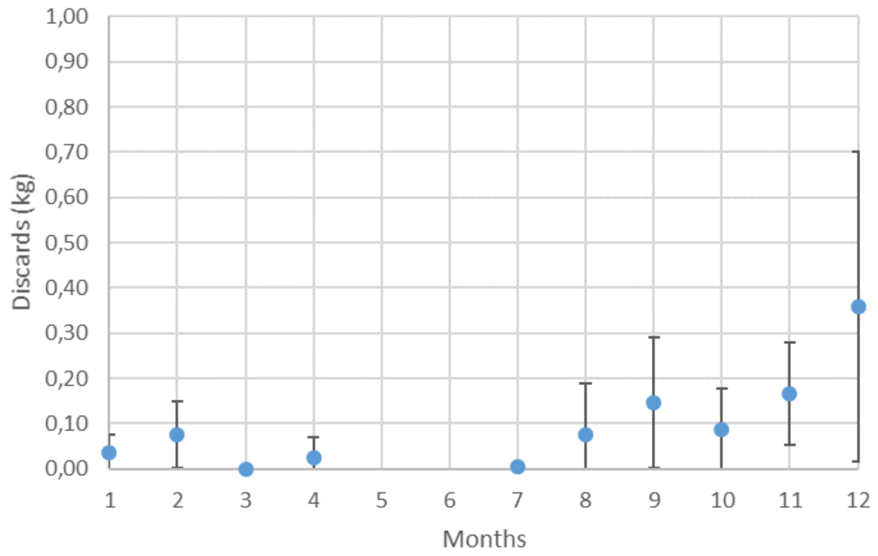


b)

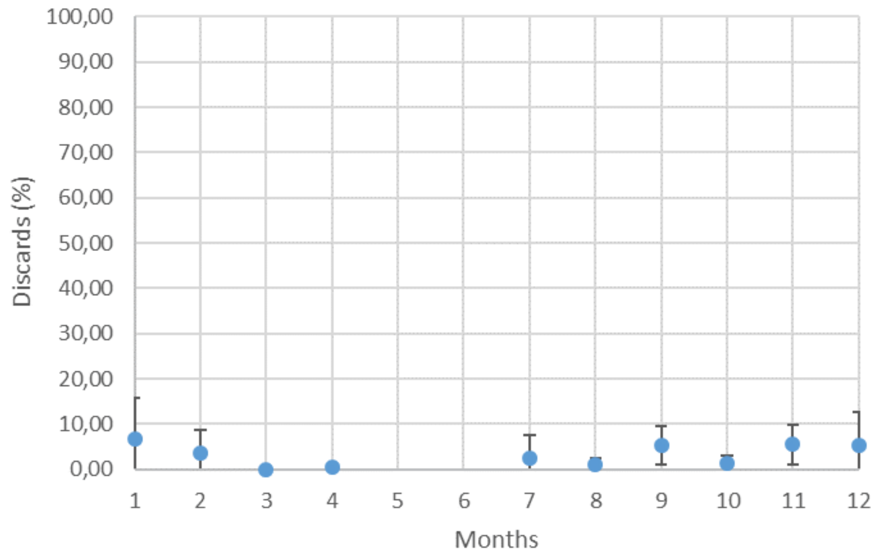


c)

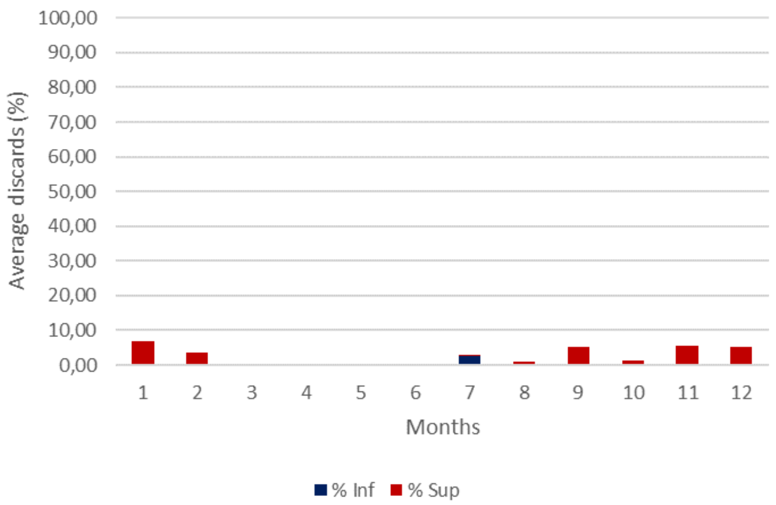
Figure 1: Annual characteristics of discards observed per fishing operation for GNS – Subarea 7: a) mean and standard error in kg; b) mean percentage and its standard error; c) cumulative mean percentage for individuals below and above the minimum commercial weight



a)



b)



c)

Figure 2: Monthly characteristics of discards observed per fishing operation for GNS – Subarea 7: a) mean and standard error in kg; b) mean percentage and its standard error; c) cumulative mean percentage for individuals below and above the minimum commercial weight

Analysis of LPUE data for Subarea 7

Search for linear relationships between variables of interest characterizing LPUE, vessel and gear characteristics, and spatio-temporal factors

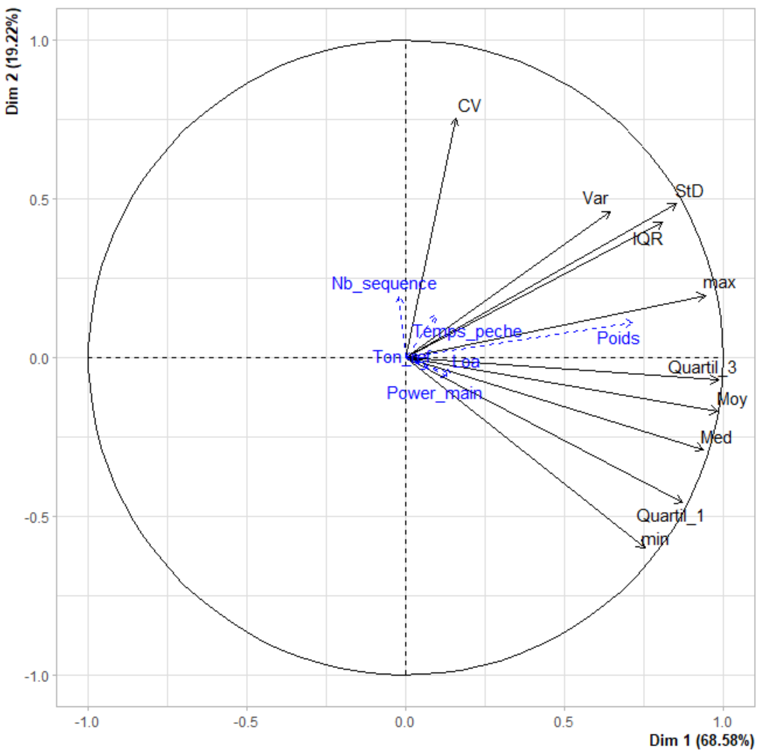


Figure 3: Correlation circle for GNS – Subarea 7 using the first two dimensions

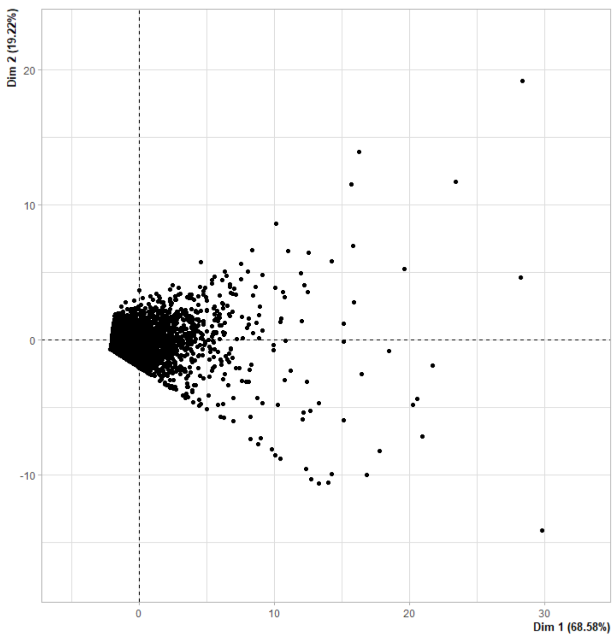


Figure 4: Individuals plot on the first factorial plane of the PCA for the "Gillnet" gear (GNS) - Subarea 7

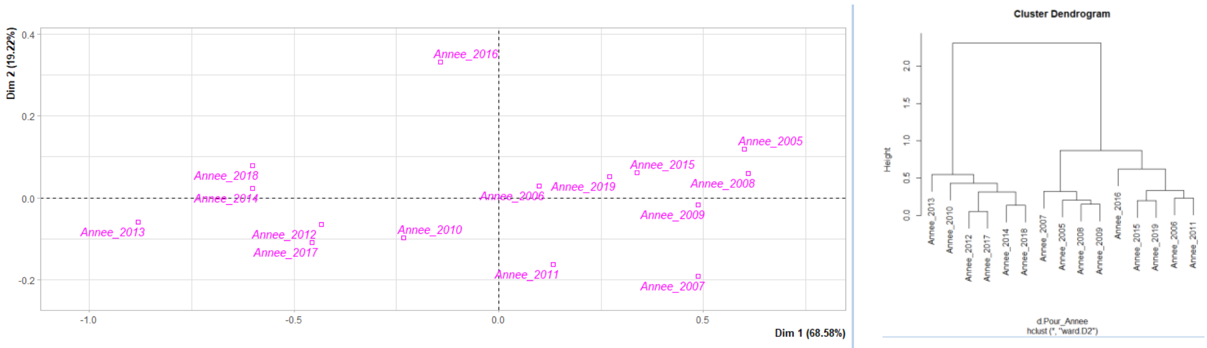


Figure 5: Barycenter plot of years on the PCA principal factorial plane and associated CAH for the " Gillnet " gear (GNS) - Subarea 7

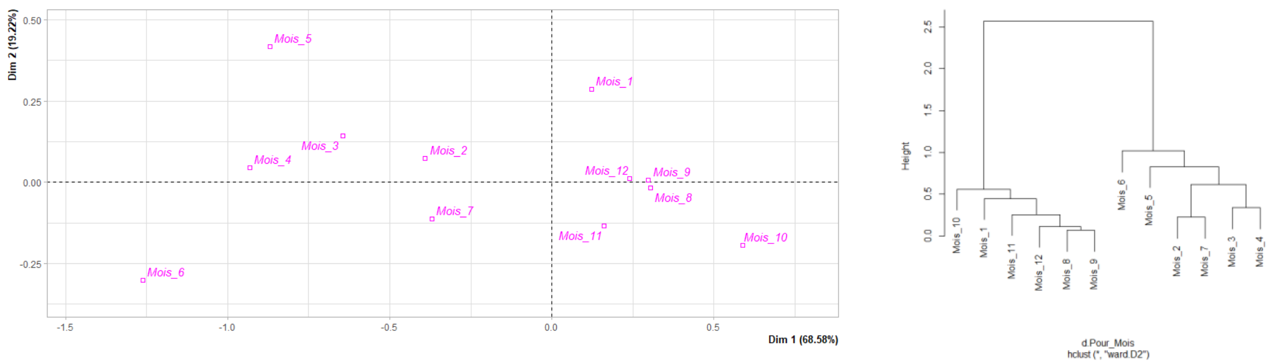


Figure 6: Barycenter plot of months on the PCA principal factorial plane and associated CAH for the " Gillnet " gear (GNS) - Subarea 7

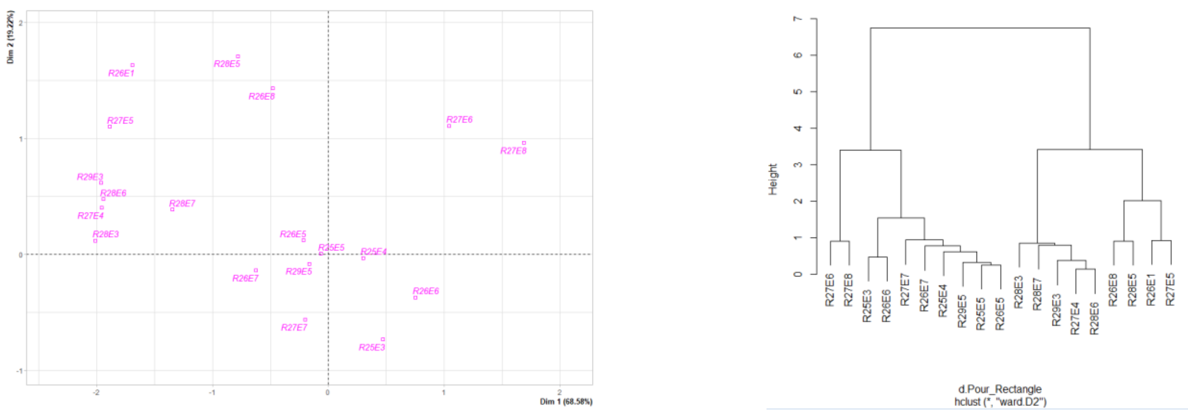


Figure 7: Barycenter plot of statistical rectangles on the PCA principal factorial plane and associated CAH for the " Gillnet " gear (GNS) - Subarea 7

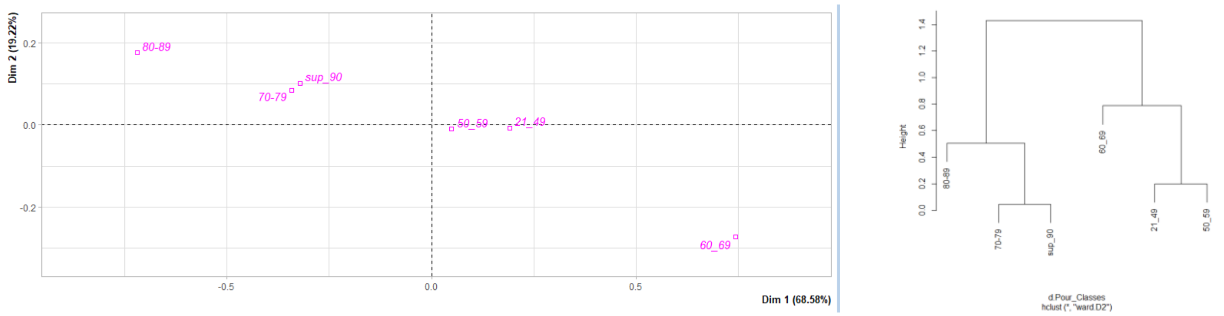
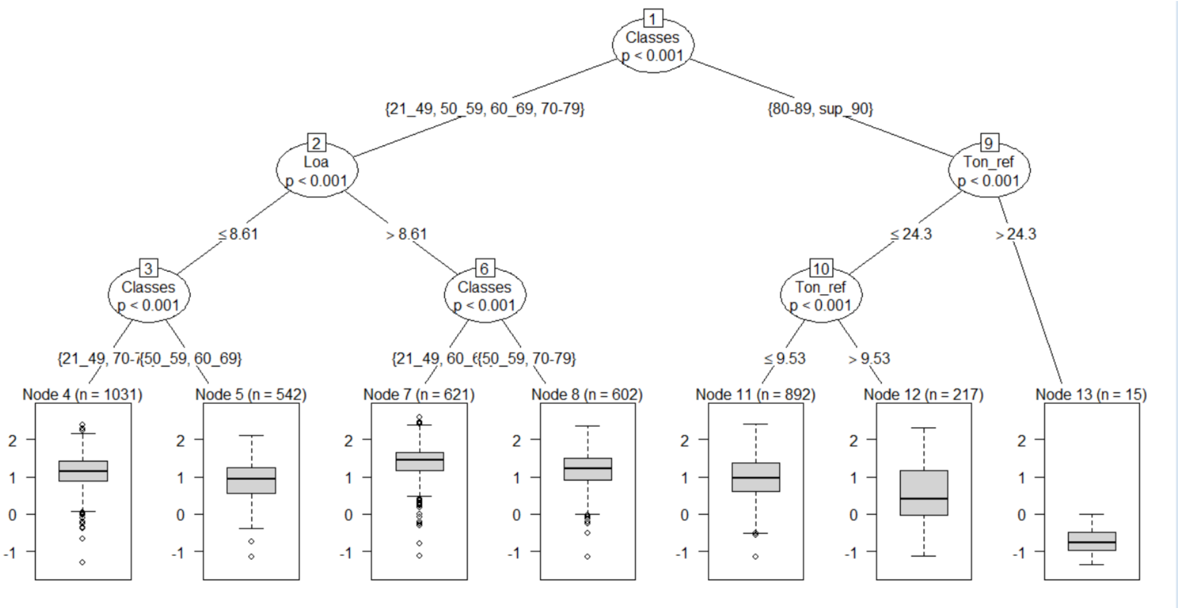


Figure 8: Barycenter plot of mesh size classes on the PCA principal factorial plane and associated CAH for the " Gillnet " gear (GNS) - Subarea 7

Search for other relationships between variables of interest characterizing LPUE, vessel and gear characteristics, and spatio-temporal factors



Moy	20.2	13.6	37.0	25.7	17.6	17.8	0.3
Med	14.0	8.9	27.9	16.0	9.4	2.6	0.2
N	1031	542	621	602	892	217	15

Figure 9: Conditional regression tree on log10Moy (standardized LPUE) with technical characteristics (the values in columns correspond to the values of each node) for GNS - Subarea 7

Analysis of LPUE data for Subareas 7-8

Search for linear relationships between variables of interest characterizing LPUE, vessel and gear characteristics, and spatio-temporal factors

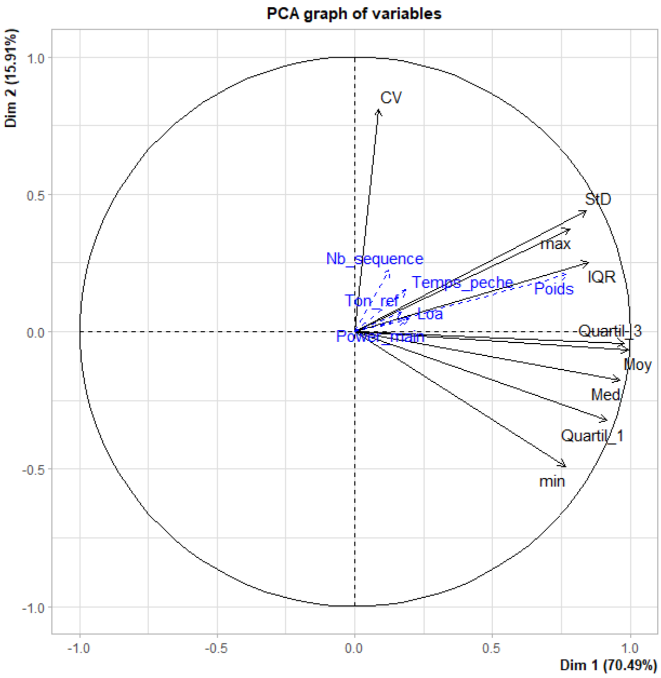


Figure 10: Correlation circle for GNS – Subareas 7-8 using the first two dimensions

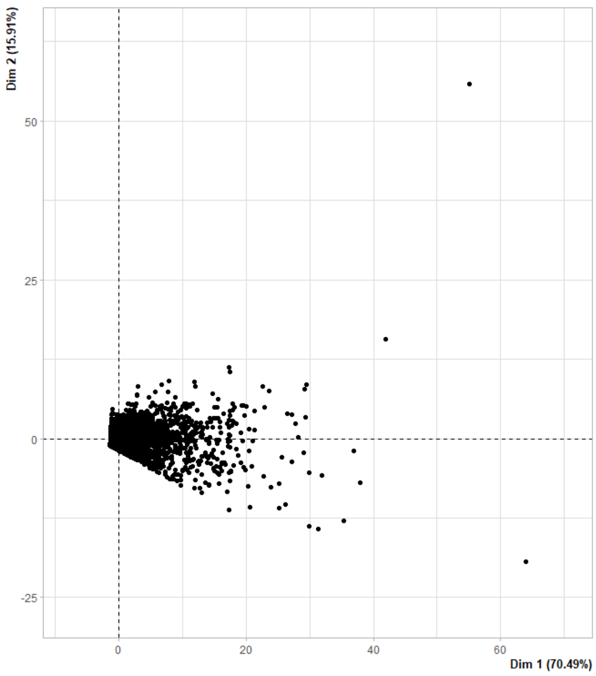


Figure 11: Individuals plot on the first factorial plane of the PCA for the "Gillnet" gear (GNS) - Subareas 7-8

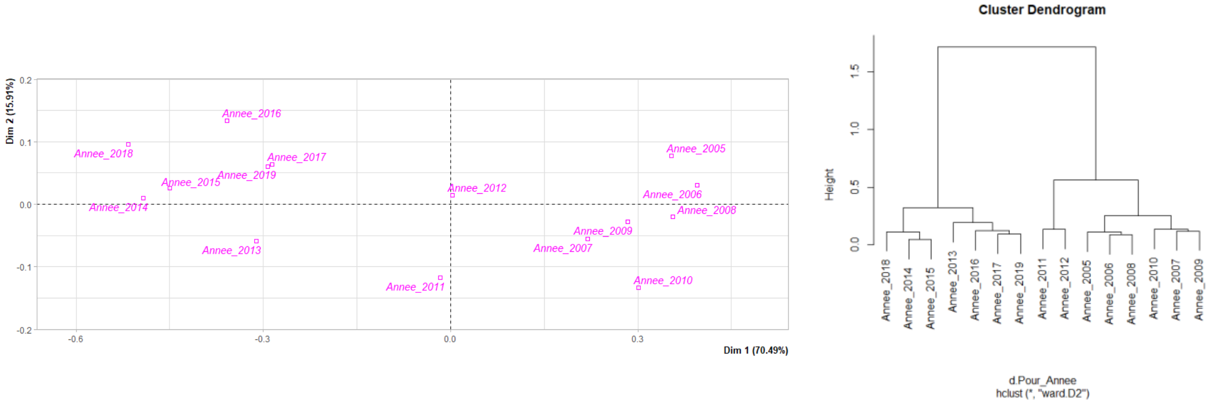


Figure 12: Barycenter plot of years on the PCA principal factorial plane and associated CAH for the " Gillnet " gear (GNS) - Subareas 7-8

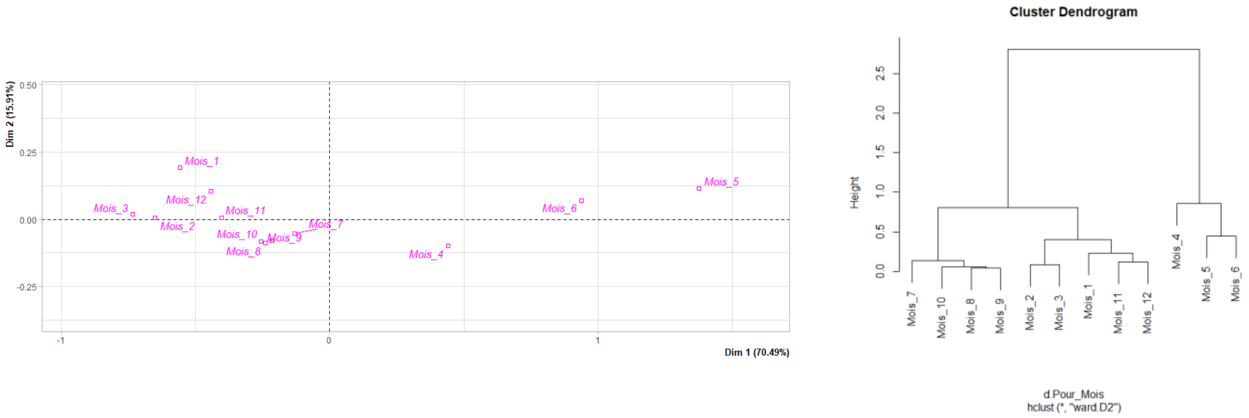


Figure 13: Barycenter plot of months on the PCA principal factorial plane and associated CAH for the " Gillnet " gear (GNS) - Subareas 7-8

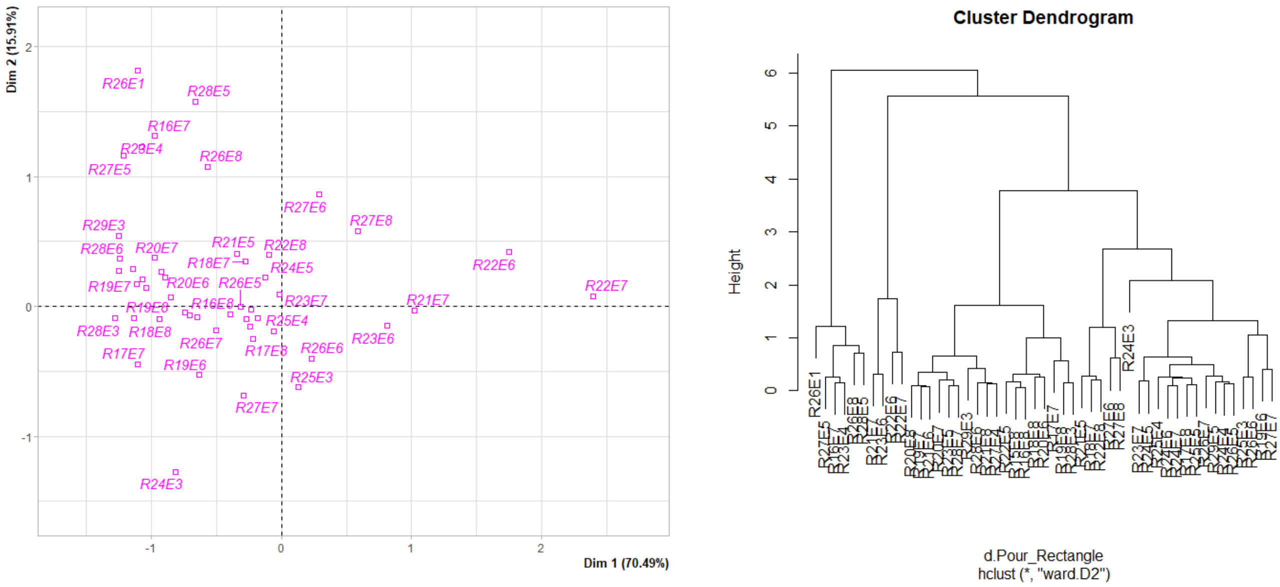


Figure 14: Barycenter plot of statistical rectangles on the PCA principal factorial plane and associated CAH for the " Gillnet " gear (GNS) - Subareas 7-8

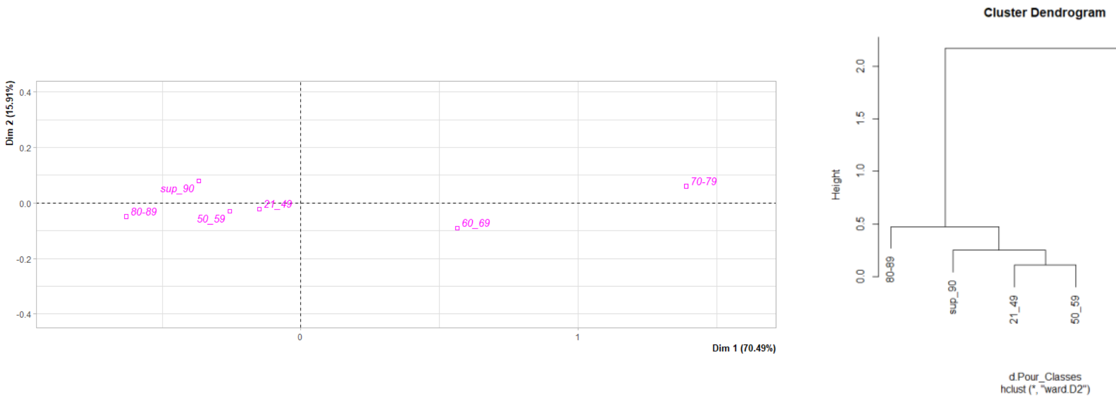
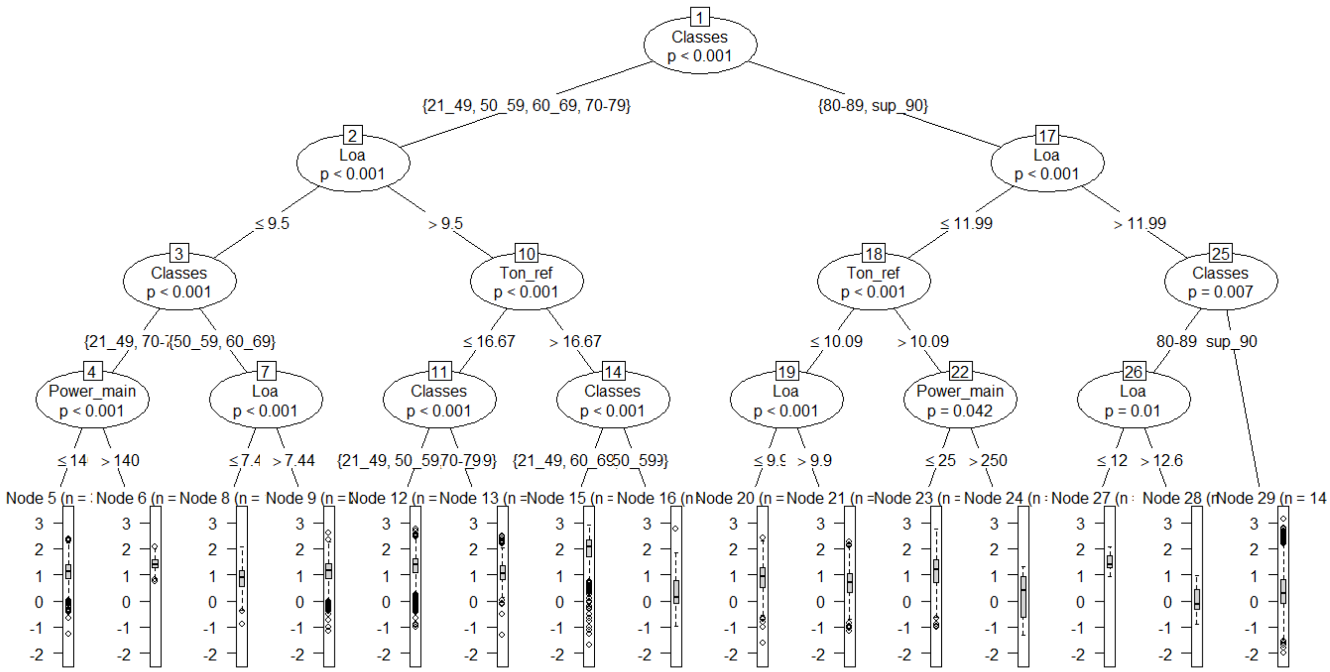


Figure 15: Barycenter plot of mesh size classes on the PCA principal factorial plane and associated CAH for the " Gillnet " gear (GNS) - Subareas 7-8

Search for other relationships between variables of interest characterizing LPUE, vessel and gear characteristics, and spatio-temporal factors



Moy	19.4	31.3	11.0	20.8	36.6	24.7	154.7	22.1	15.1	10.2	36.0	4.9	36.6	2.3	17.1
Med	13.7	24.9	7.8	14.8	23.7	11.6	118.8	1.4	8.2	5.1	15.3	2.4	23.7	0.7	1.9
N	3418	166	1503	2948	2200	295	660	39	2786	825	870	35	13	7	1448

Figure 16: Conditional regression tree on log10Moy (standardized LPUE) with technical characteristics (the values in columns correspond to the values of each node) for GNS - Subareas 7-8